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Alternative Assignment Incentive Pay Formats

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June 2005

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ALTERNATIVE ASSIGNMENT INCENTIVE PAY FORMATS

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Submitted in partial fulfillment of the requirements for the degree of

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from the

NAVAL POSTGRADAUTE SCHOOL
June 2005

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ALTERNATIVE ASSIGNMENT INCENTIVE PAY FORMATS

ABSTRACT

The purpose of this MBA professional report was to investigate and analyze experiments designed to evaluate the efficiency of alternative auction formats when auctions are used to determine individual assignments for one of several available jobs. During these assignment auctions, bids consist of compensation requests and the subjects are presented with multiple jobs over which to bid. The structure of their bids were be compared across alternative rules for determining job assignments. Also, this research report investigated and analyzed the success of the Assignment Incentive Pay (AIP) auction format. In addition, this research addressed and reviewed the Navy's current policy, guidance, and doctrine for billet assignment. Furthermore, the report's recommendations include how the U.S. Navy can effectively develop a theoretical model of bidding behavior with testable hypotheses and provide preliminary results on these hypotheses.

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Jones, Michael, LCDR	Schafer, Jason, ABFC
NPC, Pers 401	NPC P404DE2, ABF Detailer

LT Jesus S. Moreno

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LT Antonio Pinkston

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LT Walter Mainor

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I. INTRODUCTION

A. PURPOSE

This thesis will evaluate the Navy's current enlisted assignment incentive pay program and its effect on retention in the Navy's enlisted ranks. The objective of the analysis is to compare the current incentive program with alternate and possibly improved ways of conducting incentive programs. These analysis data could improve the cost effectiveness of the incentive program.

The analysis will focus on experiments designed to evaluate the efficiency of alternative auction formats when auctions are used to determine individual assignments for one of several available jobs. In these assignment auctions, bids consisted of compensation requests and the subjects were presented with multiple jobs over which to bid. The structure of their bids will be compared across alternative rules for determining job assignments.

The goal of this thesis is to analyze data from previously conducted auction experiments to determine if changes in the assignment incentive pay format could improve retention and cost effectiveness. The analysis will explore several auction design questions: how small a weight can be placed on the bid before the efficiency of the auction begins to degrade; does the type of auction chosen (i.e., first or second price sealed bid) impact the point at which a declining weight on the bid degrades efficiency of the auction; does the contention level impact auction efficiency; are there interaction effects between auction types and contention levels or bid weights? The analysis will empirically address these questions, using theoretical modeling, simulation modeling and advanced econometric analysis as appropriate and supported by the data and experimental design.

B. BACKGROUND

The Navy became an all volunteer force in 1973. After sailors finish their initial enlistment tour they must negotiate with detailers for their follow-on orders. The current job assignment system relies on a centralized, fairly static pay structure in which Sailors are largely paid according to their current rank, but little adjustment is made for hard-to-

fill locations or jobs. [1] Sometimes these orders are not desired by the Sailor or sometimes jobs went unfilled because the billet was unpopular. Added to the difficulty of the current assignment process is a robust and thriving private sector. The technical training received and experience gained by Sailors makes them highly marketable professionals for the private sector. This dichotomous correlation continues to present the Navy with retention problems, especially for those Sailors that have in-depth technical training and have completed their minimum service requirement.

To combat this problem, the Navy, with Congressional authorization, started the Assignment Incentive Pay (AIP). AIP would be paid as a monthly stipend to attract Sailors to volunteer for hard-to-fill assignments. Although current incentives allow some flexibility for location-specific reenlistment bonuses, the fact that some jobs are often filled with involuntary assignments suggests that the current set of incentives lack the flexibility required to induce voluntary assignments to undesirable billets. An auction was determined to be the best method for distributing the AIP stipends to determine the least amount of money to pay to assign a qualified sailor to those hard-to-fill jobs.

Navy enlistment and assignment quotas are driven by policy directives from the Chief of Naval Personnel in Millington, Tennessee. In determining the correct number of assignments, several factors have to be taken into consideration. For example, each sailor can only be assigned one billet even though the sailor may have placed bids on several assignments. The bid placed on the winning assignment not only affects that assignment but it affects the assignment of the other billets. Another issue in the assignment process is that the sailor's bid is only one of several factors that will weigh in on the final selection. Other factors could include the Sailor's dependents and if he meets the minimum qualifications for the billet. Analyzing the auction's behavior and refining the metrics will allow the military chain of command to make more informed decisions in an increasingly cost conscious environment. As stated by the Admiral in charge of

[1] Golfin, Peggy, et all. "Evaluation of the Assignment Incentive Pay (AIP) System," June 2004.

personnel distribution at the Navy's Bureau of Personnel (BUPERS), "Our mission is to take care of all Navy Officer and Enlisted personnel and their families, while meeting the personnel distribution needs of our Navy. We must assign all personnel in accordance with Navy directives and policies to meet both the needs of the Navy while striving to satisfy the professional and personal goals of the individual in a most responsive, courteous and service orientated manner"[2]. With a thorough understanding of the auction format and metrics, forecasting can be developed to assist in improving the cost-effectiveness of the program and improving retention.

C. RESEARCH QUESTIONS

1. How small a weight can be placed on the bid before the efficiency of the auction begins to degrade?

2. Does the type of auction chosen (i.e. first or second price sealed bid) impact the point at which a declining weight on the bid degrades efficiency of the auction?

3. Does the contention level impact auction efficiency; are there interaction effects between auction types and contention levels or bid weights?

D. SCOPE

The scope of this thesis includes: (1) evaluating the Assignment Incentive Pay (AIP) program, (2) analyzing data from previously conducted auction experiments and (3) recommending improvements to the auction based metrics system in assignment planning. Other variables that could possibly affect assignments will not be considered within the scope of this study: economic conditions in the private sector, operational tempo, quality of the tour, quality of life, etc.

Getting the right Sailor in the right job remains a high priority within the Navy's chain of command. This is especially true with Sailors that have highly involved technical and computer training costs, such as Aegis Fire Control man, all nuclear ratings and Aviation electronics. The introduction of new programs, such as perform to serve, which is a mechanism that acts as a force shaping tool by leveling rating manning from overmanned to undermanned ratings and provides quality screening by controlling

[2] PERS 4 mission statement, Admirals Corner, Bureau of Navy Personnel Command website

reenlistments for all first term sailors, demonstrates this commitment. Previous trends and data analysis show that the largest numbers of sailors elect to leave active duty at the end of their first enlistment. Normally, financial incentives, such as Selective Re-enlistment Bonuses (SRB), are used to entice sailors to remain beyond their initial enlistment.

The Navy receives significant benefits from sailors who remain in the service past their initial enlisted commitment. These benefits include decreases in future training costs, increased levels of knowledge beyond the initial enlistment and improved selectivity chances for senior rank with a larger pool from which to select.

A cost analysis was not be performed in this study because the cost of past assignments are considered sunk costs at the end of their enlistment, regardless of whether Sailors decide to leave or remain on active duty. These costs include Boot Camp, "A" and "C" schools and any other additional training required for their rating. If Sailors decide to remain on active duty beyond their initial enlistment, that provides the Navy an opportunity cost of a salary deferred by their electing to do another tour. If not, a new cost would be incurred to train new sailors and the loss of experience of that sailor. This thesis pushes forward with the belief that if improvements are made in AIP, the results could significantly improve cost savings for the Navy.

E. ORGANIZATION

Chapter II provides an overview of the auction format and the Assignment Incentive Pay Program researched in this study. The assignment requirements and process are also discussed. Chapter III discusses the experiments and metrics that were used in the research. Chapter IV reviews the analysis and findings. Chapter V contains the conclusions and recommendations.

F. SUMMARY

The purpose of this thesis is to evaluate auction bids in the current Navy's Assignment Incentive Pay program for enlisted sailors. Auction data used from previously conducted experiments are analyzed. The structures of their bids were

compared across alternative rules for determining job assignments. The scope of this study was limited to sailors competing and bidding for billets in the current AIP program.

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II. AUCTION THEORY

Auction theory centers on a market mechanism in which an object, service, or set of objects, is exchanged on the basis of bids submitted by participants. Auctions normally provide a specific set of rules that govern the procedure for the sale or purchase of an object to the participant with the most favorable bid. In his article "Vickrey Auctions in Practice: From Nineteenth Century Philately to Twenty-first Century E-commerce," David Lucking-Reiley states, "In his seminal work on auction theory, William Vickery (1961) pointed out three types of auctions used in practice: the English ascending-bid auction, the (first-price) sealed-bid auction, and the Dutch declining- price auction".3

The English ascending-bid auction process occurs when an auctioneer directs participants to beat the current, standing bid. New bids increase the current bid by a predefined increment. The auction ends when no participant is willing to outbid the current standing bid. Then, the participant who placed the current bid is the winner and pays the amount bid. Therefore, the winner ends up paying a price that is equal to the second highest bidder's value. In a first price sealed bid auction, the bidder who submits the highest bid is awarded the object being sold and pays a price equal to the amount bid. Finally the Dutch declining – price auction starts with a clock that initially indicates a price for the object for sale substantially higher than any bidder is likely to pay. Then, the clock gradually decreases the price until a bidder buzzes in or indicates his or her willingness to pay. The auction is then concluded and the winning bidder pays the amount reflected on the clock at the time he or she stopped the process by buzzing in.

The Second Price Auction is an auction in which the bidder who submitted the highest bid wins the object being sold and pays a price equal to the second highest amount bid. Alternately, in a procurement auction, the winner is the bidder who submits the lowest bid, and is paid an amount equal to the next lowest submitted bid. Normally, second-price auctions are sealed-bid, in which bidders submit bids simultaneously; their results are equivalent to English auctions, in which bidders continue to raise each other's

3 Lucking-Reiley, David Vickery Auctions in Practice: From Nineteenth Century Philately to Twenty-first Century E-commerce. Journal of Economic Perspectives, revised April 2000

bids until only one bidder remains. In Second Price Auctions, the strategy is to bid one's true value, the highest valued bidder is expected to win the auction and pay a price equal to the second highest value. Alternately, first price auctions award the object to the highest bidder, but the payment is equal to the amount bid.

A. WHY THE NAVY CHOSE FIRST-PRICE AUCTION

Despite the attractive properties of Vickery auctions (second-price auctions) are rarely seen in the business world because of susceptibility. Vickery auctions are scarce in the business world because of the bidder's fear of truthful revelation of information to the third party or the fear of auctioneer cheating. In the course of our research, we have found that bidders (those who have participated in Vickery type auctions) fear that once they have submitted their maximum willingness to pay, the auctioneer has an incentive to cheat, inflate the second-highest bid or simply withdraw the item from the auction if a high bid signals that the good may be more valuable than originally thought. Therefore, this system is totally dependent on the auctioneer's honesty. This information proves useful because if bidders fear that their sealed bids could be used against them, they will actually bid more conservatively. Therefore, Vickery auction bids are normally lower than those of first-price auction bids.

In first-price and Dutch auctions, bidders tend to behave in the same way. So, it doesn't matter which of these auctions a seller chooses nor does it matter whether the bidders have private values or share common values. The reason that a bidder behaves the same in both kinds of auctions is that they make the same decision and this decision is based upon the same information. In both auctions, a bidder knows that if they win they must pay exactly what they bid. They also know that they only win if their bid is higher than that of everyone else. The bidder must also decide upon their bid without knowing what others will do. The overall strategy for first-price auctions is difficult to specify because maximizing bid(s) depends on the actions of others. The tradeoff for the bidder is between bidding high and winning or bidding lower and receiving a higher profit if they win the auction. Theory of first-price auctions suggests that most bidders will shade their bids to move closer to the market consensus. This strategy will avoid what is know as the "winner's curse."

So, in order to assess the true impact of the auction parameters on the bidding behavior of the subjects the Bid/Reservation Wage ratio for all the winning bids is calculated. The first price (low contention) auction is the most likely auction format to be implemented in the Navy. The recently implemented Assignment Incentive Pay (AIP) program is an example of a first-price auction. "AIP attempts to enhance combat readiness by permitting market forces to efficiently distribute Sailors where they are most needed."[4] The AIP program, eligibility requirements and process are discussed in the next section.

[4] CNO guidance 2005, "Status Report."

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III. ASSIGNMENT INCENTIVE PROGRAM

A. BACKGROUND

Readiness to meet any threat to the nation's security is the primary mission of the United States Armed Forces during peacetime. Meeting the nation's security needs requires an assured cadre of experienced professionals who can fill essential and non-essential positions (billets) throughout the services. The Navy has recognized that trained and ready forces provide the flexibility necessary to shape the global environment and deter potential foes.

In 1973, the United States Navy moved from being a conscription force to being an all-volunteer force. Since 1973, sailors have entered the Navy as volunteers and have negotiated their orders through detailers (assignment coordinators). Unfortunately, the negotiation process doesn't always reflect the desires of the Sailor (service member). The Navy has recognized that Sailors do not view all assignments as equally desirable. Sailors base their selection on several factors (e.g. geographic location, type of job or nature of duty), which play a critical role when negotiating with their detailer (assignment coordinator). It is these factors that make certain assignments in the Navy less desirable and difficult to fill.

The Navy's current distribution process attempts to fill these assignments regardless of desirability, but, because of the natural dynamics of the system, less desirable assignments are more difficult to provide sufficient manning. The Navy has implemented several different incentive programs to help fill less desirable assignments. For example, sailors are often offered guaranteed follow on orders (silver bullet) to their next assignment. This method ensures that if the Sailor agrees to accept a hard-fill assignment the sailor is guaranteed orders of his or her choosing after completing the assignment. Other incentives include promotion opportunities and monetary incentives (e.g. Special Duty Assignment Pay (SDAP), Location Selective Reenlistment Bonus

(LSRB), and or Hazardous Duty Pay-Location (HDP-L)).[5] Regrettably, these incentives often to do not overcome the desirability issue(s) and often oppose the established sea and shore rotations.

In June of 2003, the Navy began offering Assignment Incentive Pay (AIP) to alleviate shortages in hard-fill assignments. AIP was initiated to "balance the playing field" and "attempt to make all assignments desirable to at least one qualified volunteer."[6] The implementation of AIP would still result in some undesirable assignments but overall it would make all assignments more desirable to at least one qualified volunteer. Also, since AIP is designed to increase volunteerism for hard-fill assignments and locations it should ultimately increase the sailors' satisfaction and improve retention for all sailors who meet the Navy's AIP eligibility requirements.

B. ASSIGNMENT INCENTIVE PAY (AIP) PROGRAM

AIP is a special pay authorized by Congress for USN/USNR enlisted active duty personnel (service members) serving in assignments designated by the respective Service Secretary. In the Navy, responsibility and policy management is assigned to OPNAV N13 (Director Military Personnel Plans and Policy Division). The AIP program is managed by a Distribution Incentives Board (DIB) which is comprised of representatives from the Fleet. Naval Personnel Command (COMNAVPERSCOM) and the Office of the Chief of Naval Operations (OPNAV) are designated to establish and provide guidance on AIP practices and procedures. They are also required to monitor the program and provide recommendations for maximum amounts and budgeting to N13. The Distribution Incentive Management System (DIMS) was developed to provide the managers (DIB, N130, and PERS 40) with a tool to aid them in efficiently administering the AIP program. DIMS is designed to track all AIP bidding activity and payments,

[5] Special Duty Assignment Pay (SDAP): available to service members who are assigned to billets authorized for SDAP, must meet eligibility requirements. SDAP is subject to Federal Withholding Tax but not FICA tax. Location Service Reenlistment Bonus (LSRB): an extension of the current Selective Reenlistment Bonus (SRB); available to service members who meet SRB requirements, subject to Federal Withholding Tax but not FICA tax. Hazardous Duty Pay-Location (HDP-L): available to service members who meet the specific requirements prescribed in DoD 7000. 14-R, Volume 7A, Section 2401; not subject to Federal Withholding Tax or FICA Tax.

[6] Jones, Michael, personal interview, 14 January 2005.

provide recommendations for maximum level changes, and provide budgeting forecasts. DIMS is designed to use activity manning trends along with bid activity to determine effective AIP levels.

The Navy designates AIP- eligible assignments (jobs) and sets a maximum monetary incentive for each job, which, by law, must not exceed $1,500 a month. Originally, during the early stages of the AIP program, the Navy based the maximum monetary incentives on an assignment's location and pay-grade. Since then, the Navy has included and offered higher incentives for certain types of assignments, particularly hard fill positions located overseas. Not all personnel assigned to an AIP location are eligible to receive AIP monthly payments. "Only personnel who have negotiated AIP assignments and are ordered to AIP locations after the implementation of the AIP program were entitled to receive monetary incentives."[7]

C. ASSIGNMENT INCENTIVE PAY (AIP) ELIGIBILITY REQUIREMENTS

AIP is designed to attract volunteers for assignments that have been traditionally difficult to fill. AIP can be used in place of or in conjunction with other monetary incentives to fill assignments designated as AIP hard-fill. Service members who wish to compete for AIP must be either U.S. Navy or U.S. Naval Reserve active- duty personnel. Also, the service member must be in a sea/shore rotation rating, qualified for the job requested, eligible for assignment in a "for duty" status and must apply for the assignment via Job Advertising and Selection System (JASS)[*see Appendix C. for JASS displays*]. Additionally, service members on their initial tours are not eligible for AIP but they may compete after completing their initial tour. Furthermore, personnel who are designated "Fit for Duty" but unsuitable for "Operational Duty" will not be allowed or entitled to compete for the monetary incentives AIP offers. Moreover, this program is not available to SELRES, FTS, TAR, IRR and ADSW* personnel. In addition, personnel

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* SELRES stands for Selected Reserve.
FTS stands for Full Time Support
TAR stands for Temporary Active Duty Reserve.
IRR stands for Individual Ready Reserve.
ADSW stands for Active Duty for Special Work.

who have been granted high year tenure (HYT) are not eligible for AIP. AIP is for those personnel who have been ordered to an authorized AIP location and are eligible to receive the entitlement.

For those who are selected for the AIP assignment, the entitlement begins when the member reports to the activity for which the incentive was awarded. The entitlement continues until the member permanently detaches from the activity and is prorated for partial months.

D. ASSIGNMENT INCENTIVE PAY (AIP) PROCESS

Traditionally, enlisted detailers are responsible for meeting the assignment request from sailors and efficiently manning the world's greatest Navy. Today's Navy demands the highest quality and best trained sailors to maintain naval readiness. Detailers review each individual's rotation window for enlisted personnel. This enables detailers to provide well-prepared sailors in proper numbers, on time (rotation) and in the most cost-effective ways possible. By effectively monitoring rotation windows, detailers are able to meet the Fleet's dynamic manning requirements, provide contact reliefs for each gaining and losing command, and provide greater career opportunities for each sailor. Normally, enlisted service members are required to submit a NAVPERS 1306/63* form (Enlisted Duty Preference Form) upon completing six months of their current duty station. Detailers use this information to match all personnel assets to Navy-wide manning requirements and try to fulfill the service member's assignment desires. If the service member does not submit a duty preference form or regularly update it, they can be assigned to a Navy top-priority billet by their detailer. This assignment process does not consider the service member's (non-volunteer) duty preferences and precludes any assignment negotiations between the detailer and the proposed service member. If detailers were continuously use this method of detailing it would have a negative affect on service member's re-enlistments and the utility of the Navy's human resources.

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* The enlisted service member must complete and submit NAVPERS 1306/63 in accordance with the Enlisted Transfer Manual (NAVPERS 15909G).

As it struggles to do more with less and meet the needs of its personnel, the Navy has undertaken an innovative approach to manning its ships with fewer hands on deck. Inspired by large commercial corporations which have attempted to improve their profit and productivity, the Navy has implemented its AIP system to better match qualified personnel to assignments, especially for assignments that have been historically difficult to fill (Navy top-priority billets). AIP is based on the principle of "supply and demand."[8] A good example of this concept is that not every service member views each assignment equally. For example, location seems to be a determining factor in whether or not a service member accepts orders to a specific assignment. Sailor (A) may see a duty location as undesirable, sailor (B) views the duty location as desirable and sailor (C) may be indifferent about the location of the billet. The AIP system is designed to capture these differences and increase the probability of finding a volunteer to fill a hard-fill assignment.

Applying for an AIP assignment is relatively easy. First, the sailor must use JASS when he or she is about nine months out from their scheduled permanent change of station (PCS). [Appendix A] Second, the sailor must review current and hot jobs available that have been designated as an AIP location. Third, if the sailor is interested in bidding for a particular billet he or she will bid in $50 increments for the position of choice. The range for bidding can be as low as $0 but may not exceed $1,500, which is the maximum congress has allowed for this monetary incentive program. Fourth, the sailor selects from the scroll down menu what he or she is willing to accept. All AIP incentive pay amounts will vary by location and position. Lastly, once all bids are in from all qualified personnel the detailer will make the final selection based on the range of qualified bids, PCS cost and any additional factors pertaining to each position. Generally, the qualified sailor with the lowest bid (total cost) is selected. Once the sailor is selected for an AIP assignment, he or she is issued PCS orders that include the AIP to which the sailor is entitled for that particular assignment. Upon receipt of these orders, the sailor signs an agreement and acknowledges the assignment location, duration and AIP amount to be accepted on a monthly basis. Although this type of electronic bidding

[8] Golfin, Peggy, et all. "Evaluation of the Assignment Incentive Pay (AIP) System," June 2004

is only used for AIP authorized positions, it may one day become the Navy's normal day-to-day detailing process for posting and assigning sea and shore based positions.

E. ANALYSIS REVIEW

In June 2004, the Center for Naval Analysis (CNA) evaluated the Navy's AIP system. They examined many aspects of the AIP system, but this section of the paper will focus on JASS participation between various pay grades, fill rates, and effects of raising the cap per assignment. In addition, CNA recognized that when converting billets from Type 3 (sea duty) to Type 6 (overseas shore duty), AIP was very cost effective.[9]

All sailors have the choice of negotiating their next assignment with their detailer, but if they choose to apply for an AIP assignment they must use the Job Advertising and Selection System (JASS)[10]. JASS is a software application that is available on the Naval Personnel Command's website for enlisted sailors to review and apply for available billets. Therefore, it is important to understand who has access to JASS, who uses JASS and examine whether the implementation of AIP has increased JASS usage. Accessibility to the JASS system is open to all sailors who desire to electronically detail their next assignment. Once on JASS, the sailor can view all billets posted on JASS or choose the AIP option if he or she is interested in an AIP assignment. A factor to consider when assessing JASS usage is the fact that some sailors are stationed overseas and subject to time zone differences. These time zone differences have no affect on the accessibility to JASS but do affect the accessibility to detailers. For example, if the sailor has a specific question about an AIP assignment he or she may be unable to contact their detailer. CNA stated that "the difficulty of sailors stationed overseas is not accessing JASS but in accessing a detailer on the phone."[11] Therefore, the only possible restriction

[9] For reference, Type 1 jobs are continental United States (CONUS) shore duty; Type 2 are CONUS sea duty; Type 3 are outside CONUS (OCONUS) shore jobs that are given sea duty credit; Type 4 are OCONUS sea duty; and Type 6 are OCONUS shore duty.

[10] JASS has been replaced by JCMS (JASS Career Management System). JCMS is designed to enable Sailors and Commands to identify the best job for the Sailor and best Sailor for the command. JCMS is designed to provide a bridge between existing legacy distribution systems and the Career Management System functionality of Sea Warrior.

[11] Golfin, Peggy, et all. "Evaluation of the Assignment Incentive Pay (AIP) System," June 2004.

in accessibility to JASS would be a technical limitation that prevents sailors from uploading the JASS web site.

CNA also discovered variations in JASS usage between pay grades. Their findings indicated that junior sailors have a tendency to use JASS more often than senior sailors. This variance is due to senior sailors feeling more comfortable speaking to their detailer when searching and negotiating for career enhancing orders vice accepting an AIP assignment that may not be career enhancing. Since detailers have direct control of the distribution process, senior sailors see that it is imperative for them to speak directly to their detailer when shaping their careers and family needs.

Unfortunately, CNA was hampered in measuring JASS usage because of data limitations. Data limitations reflect the recent implementation of the AIP system. Since AIP was implemented in March 2004 and the CNA analysis was conducted and reported in June 2004, insufficient time had elapsed for CNA to collect enough numerical data to accurately assess JASS usage. Due to the data limitations, CNA was only able to analyze those sailors that had at least submitted one application on JASS. Therefore, insufficient data "limits our analysis because it means that we cannot identify the absolute level of JASS usage, and we can only evaluate relative differences in application rates across various Sailor characteristics or over time."[12] Moreover, CNA was unable to extrapolate their findings to determine whether AIP assignments were undesirable or if differences existed between pay grades, ratings or duty type (sea/shore codes). The analysis did reveal that implementation of AIP effectively increased usage rates among the various pay grades and ratings but it was also evident (as mentioned above) that certain groups of Sailors preferred to be directly detailed vice applying on JASS. Understanding who has access to JASS, who uses JASS and if the implementation of AIP had increased JASS usage could assist detailers in meeting manning requirements.

The readiness of this nation is solely based on the effectiveness of meeting manning requirements. Therefore, people and personnel are the single most important factors of military readiness and placing them in the right positions is imperative to the

[12] Golfin, Peggy, et all. "Evaluation of the Assignment Incentive Pay (AIP) System," June 2004.

success of this nation's security. Therefore, by allowing sailors to set their prices, through a bidding process for an assignment selected as a hard-fill job or location will increase fill rate percentages for those assignments considered undesirable. There are many factors that affect the Navy's ability to increase fill rates for all commands. For example, every pay grade and rating views locations or jobs differently. Also, decreasing or increasing CAP* levels for specific locations or jobs would have an overall affect on fill rates. Furthermore, increasing fill rates can be complicated by other trade-offs or factors, such as PCS funding availability, job availability for various pay grades or ratings and eligibility requirements. AIP is a fairly new program and because of its implementation there is a strong indication that fill rates have increased and will continue to increase for locations and jobs authorized as AIP assignments. Unfortunately, since AIP had only been in existence for 10 months when CNA conducted their analysis, it was difficult to determine whether or not AIP had contributed to the increased fill rates. As more time elapses, AIP becomes more popular and participation increases, there will be more complete data available to truly assess whether manning in AIP locations has increased because of AIP implementation.

Earlier in this section we mentioned that raising the cap affects the ability to increase fill rate percentages. Raising the cap increases the probability of increasing fill rates because it induces an increase in application rate. For instance, CNA discovered that when a cap was raised by $300 dollars there was a 52% increase in applications and a 115% increase in fill rates. This is extremely important to the Navy because it "suggest[s] that the Navy could consider a cap increase when more applications or a higher fill rate is required."[13] This information can be used strategically to increase manning levels for commands that are historically difficult to fill. The CNA's analysis suggests that increasing the cap ultimately increases the application pool of those interested and qualified for that particular assignment. "Raising the AIP cap allows each sailor to find a job that best matches his or her preferences, until there is an optimal

* For our purposes we define CAP as the maximum amount of monetary incentive the Navy is willing to pay for a specific billet in a designated location.

[13] Golfin, Peggy, et all. "Evaluation of the Assignment Incentive Pay (AIP) System," June 2004, pg 20.

match of jobs and sailors, and no one is assigned involuntarily."[14] In spite of this, the Navy must be careful when raising the cap that it doesn't create gapped billets. This can occur if there are more jobs than available sailors. By raising the cap it could create gaps in other locations which would ultimately lead to involuntary assignments. Also, the Navy must scrutinize all raised caps per location and job to ensure that it does not exceed the cost-effectiveness of AIP.

The overall cost effectiveness of AIP has been impressive. CNA rationalized that the AIP program was not only developed to increase volunteerism but to begin eliminating Type 3 duty (sea duty) and replacing it with Type 6 duty (shore duty). Remember that sailors were offered shore duty billets with sea duty credit (authorized sea pay) as an incentive to accept hard-fill assignments. AIP allows the Navy the opportunity to convert 8,800 Type 3 billets into Type 6 billets. This conversion enables the Navy to outsource the Type 6 billets and save an estimated $195 million dollars annually. Also, converting 8,800 positions into Type 6 billets increases the sailors available for actual sea duty billets. Finally, the AIP program is a much more efficient incentive than sea duty credit for overseas assignments. Analysis conducted by the Center for Naval Analyses (CNA) revealed, "Using an efficient market system in which AIP is targeted by billet, the cost of getting volunteers for OCONUS (Overseas Continental United States) billets would probably be below $25 million annually. The sea duty credit (costing $83 million annually at a minimum) is at least three times more costly than AIP. Even under a worst case scenario, assuming all OCONUS shore billets that receive sea duty credit were paid AIP of $750 per month, AIP should be cost-effective."[15] As stated in an earlier section, the average AIP bid (generally about $350 a month) has been much less than $750 per month; accordingly CNA's analysis understates the relative efficiency of AIP versus sea duty credit.

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[14] Golfin, Peggy, et all. "Evaluation of the Assignment Incentive Pay (AIP) System,"

June 2004, pg 24.

[15] CNA Report – Transforming the Assignment System: Will Incentives Reduce Critical Shortages? – CRM D0007147.A2, December 2002

F. SYNOPSIS

Our analysis concludes that AIP has demonstrated significant benefits for the Navy's personnel distribution system and it should continue to evolve as time elapses. AIP has proven that it can be an effective tool to persuade sailors to apply and accept hard-fill assignments. Thus, the Navy should continue to monitor and analyze sailor application behaviors. The Navy must focus on variations that may exist between various ratings and pay grades and the effects of raising and lowering the monetary incentive. These data will prove useful to the detailers in predicting which assignments will be difficult to fill and determining what measures must be taken to increase the probability of receiving at least one voluntary qualified sailor application.

AIP allows the Navy the opportunity to convert positions from Type 3 to Type 6 positions. This conversion (for OCONUS positions) will enable the Navy to save millions of dollars annually. Furthermore, as a result of the type duty conversion, the Navy will have an estimated 8,800 additional sailors available for sea duty assignments. Therefore, improving future readiness and providing more at sea training opportunities for sailors. Moreover, the research indicates that the effectiveness of AIP can be increased by adjusting cap rates methodically or by offering sailors lump-sum payments vice monthly incentives.

AIP is in its infancy and it is far too early to fully assess the total utility of AIP. As time elapses and more data becomes available, we may discover that AIP has an overwhelming positive effect on retention and manning. Currently, data reflect that Sailor's who are aware of or have directly participated in this new assignment initiative indicate that they are extremely supportive of the AIP program. "The AIP program is giving more Sailors a choice in their duty assignments and promises to increase the quality of life and career satisfaction of sailors and their families."[16]

The importance of understanding the many factors (e.g. sailor characteristics, performance measurements, and measurements of effectiveness) that contribute to the

[16] Kelly, Mike, LCDR (N13). "Draft AIP Report to Congress." E-mail to Michael.T.Jones@navy.mil. 01 April 2005.

limitations and the success of AIP is that it will assist us in analyzing data from previously conducted auction experiments. The next section will explore several auction design questions and address issues and concerns surrounding the performance measurements for evaluating alternative auction formats employed in experimental analysis of the U. S. Navy's Assignment Incentive Pay auctions.

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IV. EXPERIMENTAL ANALYSIS

A. GENERAL

This study will analyze experiments to evaluate the efficiency of alternative auction formats when auctions are used to determine individual assignments for one of several available billets (jobs). In these assignment auctions, bids consist of compensation requests and the participants are presented with numerous billet opportunities on which to bid. The structure of their bids will be compared across alternative rules for determining billet assignment.

B. INTENTIONS

This effort will analyze data from previously conducted auction experiments. The analysis will explore several auction design questions: how small a weight can be placed on the bid before the efficiency of the auction begins to degrade; does the type of auction chosen (i.e. first or second price sealed bid) impact the point at which a declining weight on the bid degrades efficiency of the auction; does the contention level impact auction efficiency; are there interaction effects between auction types and contention levels or bid weights? The analysis will empirically address these questions, using theoretical modeling, simulation modeling and advanced econometric analysis as appropriate and supported by the data and experimental design. The final report will develop a theoretical model of bidding behavior with testable hypotheses, and provide preliminary results on these hypotheses.

C. INSTRUCTIONS FOR THE EXPERIMENTAL AUCTION

Instructions for the experimental auction are found in an appendix but are discussed here. Each participate (sailor) in the experiment made decisions in this experimental auction. There were 5 other participants (6 total) which were gathered as candidates to fill 5 fictitious jobs (billets) for low contention cases and 3 fictitious jobs for high contention cases. The decision to only use 6 participants in this study is because on average there is only a small group of “actual sailors” that compete for online billets. Whether or not they were selected for a particular billet in part depended on how qualified they were for the billet (as expressed by a fitness score randomly generated by the software) and how willing they were to take the job (as expressed by how low their

bid is for the billet). The greater the bid for a job, the more money the participant received if selected. On other hand, bidding high for a job made it less likely that they were selected for that job. Bidding high on all jobs made it more likely that the participant was unassigned. If not assigned to a billet, the participant did not earn any money in that auction and incurred a penalty of $0.30.

Each participant's "bids and profits in these auctions will be in terms of Gamebucks, converted into U.S. dollars at a rate of U.S. dollars/Gamebucks = 0.10. In other words, if the participant were to earn 10 Gamebucks in profit he or she would earn $1.00 in U.S. dollars." Each participant is guaranteed $13 for participating in the experimental auction, but has the opportunity to earn more.

1. C.1 Data

The data for evaluation were derived from an experiment conducted at several universities (University of Memphis, Southern Methodist University (SMU) and The University of Mississippi). The purpose of the experimental auction is to match Sailors to billets and "evaluate the comparative ability of alternative auction mechanisms to achieve effective labor assignment."[17] The experiment lasted 60-90 minutes in duration and involved six participants (sailors) competing in a series of 20 auctions. Each auction was run in succession but independent of one another. Each sailor competed for either three of six billets in which they would be assigned to one of those billets based off of their maximum bid (reservation wage) and fitness score. Therefore, the winning bidders would be assigned to a billet and paid accordingly (their lowest acceptable bid). For each losing bidder, he or she will not be assigned to a billet and will not receive any payment. In each auction there will be either three or six winning bidders and three or one losing bidders. The following section introduces and explains the metrics to be used to measure auction effectiveness.

[17] Smith, James, L. "*The Design of Experiments to measure and assess the efficiency of Alternative Assignment Auction Formats*" September 2003, pg 1.

D. MEASURES OF AUCTION PERFORMANCE

This section proposes performance measures for evaluating the alternative auction formats employed in experimental analysis of the U.S. Navy's Assignment Incentive Pay auctions. In particular, we expand on "measures of auction effectiveness" put forward in "The Design of Experiments to Measure and Assess the Efficiency of Alternative Assignment Auction Formats" by James L. Smith (September 8, 2003)."

The discussion is separated into the following sections:

- Relevant notation
- Understanding the "efficient outcome"
- Normalization/indexing of performance measures
- Analysis of specific performance measures

E. RELEVANT NOTATION

- c_{ijk} = reservation wage of sailor i for billet j as assigned (randomly ex ante) for auction k
- f_{ijk} = fitness score of sailor i for billet j as assigned (randomly ex ante) for auction k
- b_{ijk} = bid by sailor i for billet j during auction k
- s_{min} = minimum allowed bid
- s_{max} = maximum allowed bid
- s_{ijk} = salary/wage paid to sailor i for billet j as a result of auction k
- z_{ijk} = aggregate score of sailor i for billet j during auction k
    - o = $100\alpha(1- b_{ijk}/s_{max})+(1-\alpha)f_{ijk}$
- x_{ijk} = billet assignment identification function
    - o = 1 if sailor i is assigned billet j during auction k
    - o = 0 otherwise

F. UNDERSTANDING THE "EFFICIENT OUTCOME"

1. Background

a. The definition and nature of the "efficient outcome" is critically important in this discussion because almost all of the performance measures analyzed below use some measurement of performance at this outcome as a denominator or, more generally, as a way to index or scale the performance measures.

b. The "efficient outcome" of the auction could be defined as the assignment and associated pay levels that would occur if all subject/sailor bids were replaced by true reservation wages, such that the "efficient score" of sailor i for billet j during auction k is given by $100\alpha(1- c_{ijk}/s_{max})+(1-\alpha)f_{ijk}$. However, it is not clear in what sense the above described outcome is "efficient." The efficient outcome is traditionally defined as the outcome which maximizes total surplus. In this case, total surplus would be the sum of the surpluses enjoyed by each sailor (actual wage minus reservation wage for assigned billet) plus the surplus or utility of the Navy. It is not clear, however, that the above defined "efficient outcome" actually incorporates either sailor or Navy surplus/utility. There is certainly something appealing about the billet assignment that results from sailors bidding their true reservation wages (in the sense that it maximizes some type of "true" score), but we should be careful about calling this outcome "efficient." Labeling the defined outcome as the "focal outcome" or "index outcome" or "baseline outcome" might be more appropriate.

c. Obviously, an efficient outcome can only be defined if every party's utility function (or surplus) is well-defined. Sailor utility is clear: actual wage minus reservation wage for assigned billet. Navy utility, however, is unclear. The Navy cares about both fitness scores and wages paid. At first, it may seem reasonable to define Navy utility from auction k as Z_k which is the sum of the realized scores across sailors given by:

$$Z_k = \sum_{i=1}^{6}\sum_{j=1}^{J}\left(100\alpha\left(1-b_{ijk}/s_{\max}\right)+\left(1-\alpha\right)f_{ijk}\right)x_{ijk}$$

This definition of Navy utility, however, is problematic for three main reasons:

Under the second price auction, sailor salaries are not equal to their bids, so perhaps the b_{ijk} values in the formula above should be replaced by s_{ijk} values, because presumably the Navy's utility function must incorporate actual salaries paid. This being the case, of course, begs the question of why aggregate scores are the same under the first and second price auction.

If Navy utility is defined as Z_k or some slight modification thereof, then the question of which value of α is optimal from the Navy's perspective (one of the main proposed research questions) is a non-sequitur. The optimal value of α should be exactly the true value of α in the Navy's utility function. Whereas it can be argued that the true value of α in the Navy's utility function is unknown, this would make it impossible to identify the optimal outcome from the Navy's perspective as well as impossible to define the efficient outcome, returning us to the original problem.

If Navy utility is defined as Z_k (or by Z_k with b_{ijk} in the formula replaced by s_{ijk}) and the sailor's utility is defined as $s_{ijk} - c_{ijk}$, then each dollar of salary is worth $100\alpha / s_{max}$ to the Navy while it is worth \$1 to the sailor. Since $100\alpha / s_{max} \neq 1$ in all but knife-edge cases, total surplus is always increased by either paying all sailors an infinite salary (or whatever the upper bound is) or by compelling all sailors to take the lowest possible salary, even negative if that is possible. Obviously, these are unreasonable as "efficient outcomes" and, moreover, we would probably like to consider total efficiency independent of simple transfers of money. In other words, we would probably want a dollar to have the same value to all, even though this is commonly violated by varying wealth effects, risk aversion, opportunity costs, etc.

That proper definition of the Navy's utility function is not only important for identifying the "true" efficient outcome that maximizes total surplus, but also for identification of the optimal auction mechanism from the Navy's perspective. It is clear ex ante that the performance measures described below will rank the various auctions quite differently, with some pairs of measures likely selecting diametrically opposed rankings. Thus, an overall Navy utility function would also allow for better weighing of alternative mechanisms.

We propose, therefore, that Navy utility from auction k be defined as Z_k^* where:

$$Z_k^* = \sum_{i=1}^{6}\sum_{j=1}^{J}\left(100\alpha\left(1-s_{ijk}/s_{\max}\right)+\left(1-\alpha\right)f_{ijk}\right)x_{ijk}\ .$$

In other words, Z_k^* = Z_k with b_{ijk} in the formula replaced by s_{ijk}. To overcome the problem identified in point (2)(c) above, we propose that sailor i's utility from auction k be defined as u_{ik} where:

$$u_{ik} = \sum_{j=1}^{J} 100\alpha x_{ijk}\left(s_{ijk}-c_{ijk}\right)/s_{\max}\ .$$

In other words, u_{ik} is simply sailor i's surplus from his actual assignment j (s_{ijk}-c_{ijk}) multiplied by $100\alpha/s_{max}$, which scales his utility appropriately such that both sailors and the Navy value a dollar equally, eliminating "corner solution", efficient outcomes involving infinitely positive or negative salaries.

With utilities so defined, we can now define the true efficient outcome(s) of auction k as the outcome(s) which maximizes total surplus TS_k given by:

$$TS_k = Z_k^* + \sum_{i=1}^{6} u_{ik}$$

$$TS_k = \sum_{i=1}^{6}\sum_{j=1}^{J}\left(100\alpha\left(1-s_{ijk}/s_{\max}\right)+\left(1-\alpha\right)f_{ijk}\right)x_{ijk} + \sum_{i=1}^{6}\sum_{j=1}^{J} 100\alpha x_{ijk}\left(s_{ijk}-c_{ijk}\right)/s_{\max}$$

$$TS_k = \sum_{i=1}^{6}\sum_{j=1}^{J}\left(100\alpha\left(1-c_{ijk}/s_{\max}\right)+\left(1-\alpha\right)f_{ijk}\right)x_{ijk}$$

This yields exactly the assignment that was originally proposed as part of the "efficient outcome," (partially) rehabilitating the original concept. However, this "efficient outcome" is unique only in its assignment. After scaling sailor utilities, a dollar is now worth the same to the Navy as it is to any sailor. Therefore, any salary arrangement for the above defined assignment will be efficient: Total surplus is unaffected by simple transfers of money from the Navy to any sailor or vice versa. Thus, it is appropriate to refer to a unique "efficient assignment" but not a unique "efficient outcome" where the notion of outcome includes a set of sailor salaries.

G. NORMALIZATION/INDEXING OF PERFORMANCE MEASURES

1. Background

a. All of the performance measures proposed here are normalized or indexed by dividing the gross measurement by a "baseline" measurement.

b. Such normalization is presumably intended to (a) present the value of a measure relative to some well-understood "baseline" scenario and (b) facilitate comparisons of alternative auction mechanisms within and across different performance measures.

c. Normalization of performance measures facilitates comparisons across different measures only when performance values have substantially the same meaning across measures. For example, if a high value is "good" in one measure a high value should be "good" in other measures as well whenever the normalizations are intended to facilitate cross-measure comparisons. Moreover, if some normalized measures are constrained between zero and one, they should all be simultaneously constrained. Without these consistencies it makes comparisons across measures very difficult. In the analysis below, we propose alternative normalizations that provide this consistency.

H. ANALYSIS OF SPECIFIC PERFORMANCE MEASURES

Measure name

Total Wage Bill (WB)

Quality to be measured

The Navy's total monetary cost of filling the available billets

Discussion

a. All else equal, a high value of WB is bad from the Navy's perspective. This is important to consider when making comparisons with other performance measures where high values are good from the Navy's perspective.

b. In this analysis, total wage bill will be normalized by dividing by the total wage bill when (a) each sailor is paid his/her reservation wage, and (b) sailors are assigned to the available billets such that the lowest sum of reservation wages is

achieved. The index or baseline outcome in this case is the minimum-cost voluntary-participation outcome. This has the advantage of being both a feasible outcome and a true minimum achievable total wage bill. However, the total wage bill is likely to be significantly higher than the minimum cost voluntary-participation outcome, so this normalized measure would be greater than one. Inverting the measure (flipping the numerator and denominator) would add the additional normalizing feature of scaling all values between 0 and 1 with higher values being better from the Navy's perspective.

c. In sum, we propose the following wage bill performance measure for a given auction k:

$$WB_k = \frac{WB'_k}{\sum_{i=1}^{6}\sum_{j=1}^{J} s_{ijk}\, x_{ijk}}$$

Where WB'_k is the minimum-cost voluntary-participation total wage bill described above.

Measure name

Total Fitness Level (TF)

Quality to be measured

Extent to which Sailors are qualified for the billets to which they are assigned by the auction mechanism in force.

Discussion

a. As with the previous performance measure, it again seems appropriate to normalize a total fitness level performance measure by the maximum/minimum feasible value. Because "bigger is better" in this measure, the maximum feasible value seems appropriate, and it is very simple in any auction to identify the billet allocation/assignment that maximizes the sum of all fitness scores across assigned billets.

b. Thus, we propose the following performance measure of total fitness in auction k:

$$TF_k = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J} f_{ijk} x_{ijk}}{TF_k'}$$

Where TF_k' is the maximum feasible total fitness as described above.

Measure name

Overall Score (OE)

Quality to be measured

Extent to which a particular mechanism achieves the 'ideal' value of the objective function.

Mathematical formula

$$OE = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} Z_{ijk} x_{ijk}}{OE^*}$$

Discussion

a. This performance measure evaluates how well the auction "scored" relative to the maximum possible total score achievable, which is reached at the previously described "efficient outcome."

b. In this case, the use of the "efficient outcome" (z*) as a normalization is appropriate because this measure is about evaluating how close an auction comes to this outcome. Moreover, the measure appropriately normalizes values between 0 and 1 with higher values representing better performance. It is therefore comparable to all of the previous revised measures we have proposed.

Measure name

Bidding Factor (BF)

Quality to be measured

Bid inflation relative to true reservation wages.

Mathematical formula

$$BF = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} b_{ijk}}{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} c_{ijk}}$$

Discussion

a. As opposed to other measures, this performance measure takes on values greater than one which is more appropriate in this context; moreover, all realized values of this measure are constrained to be no less than one (which is appealing).

Summary

The idea here is, of course, to establish a set of measures that enables the project team to accurately monitor and effectively analyze the assignment auction experiment. Once the metrics are gathered, the numbers can be used to formulate an overall conclusion about the overall bidding behavior and the effects of auction design.

I. EXPERIMENTAL AUCTION RESULTS

The auction data were derived from various experiments conducted at three separate universities at three different geographical areas with different proctors. However, the experimental data were consolidated and analyze as a whole. It is important to note that each university conducted their respective auction experiments using different fitness versus bid weights (F&B) weights than the other universities. As a result, the total data collected spanned six different F&B weight categories of F20/B80, F34/B66, F50/B50, F66/B34, F80/F20, F90/B10 and their decision variables of Overall Efficiency, Fitness, Wage Bill, and Bid Factor All. The Solver add-in function with a VBA macro within Microsoft Excel was used to optimize the efficiency assignments of

the numerical data derived from the experimental auction. Determining the optimal efficiency assignments for each variable and optimal weight within that variable allows the research group to determine what the most efficient auction format is for the Navy and sailor. For all intents and purposes, contention levels reflect actual supply demand balances and thus are not a realistic controllable variable for the Navy. The mean and standard deviation were determined to analyze common trends and compare various auctions overall efficiency.

1. Fitness Score

As the weight assignment is shifted from fitness to bid, the Fit efficiency increases across all variables. In each individual matrix, Fit increases from low to high contention and from 1st to 2nd price auction until F66/B34 where no specific pattern is recognized. The highest Fit outcome for each matrix is in the 2nd price auction field.

The 2x2 matrix table, which displays the mean in the top portion of each section and the standard deviation in bottom portion, proposes that participants with high fitness scores, no matter what contention level or auction format have a high chance of being selected regardless of auction format or contention level will have a better opportunity for selection. The Navy's goal directed by the Chief of Naval Operation (CNO) is to place "the right sailor in the right job at the right time" therefore, fitness score is integral in the auction process. As illustrated in figure 1.1 below, since the fitness score is relatively high across all weights, contentions, and formats; it can be ignored in lieu of the optimization of other variables.

20/80

Contention	1st	2nd	Auction Format
Low	0.953976997	0.963171919	
	0.02734416	0.028533753	
High	0.944963992	0.959773445	
	0.034633707	0.027910498	

66/34

Contention	1st	2nd	Auction Format
Low	0.989433098	0.988383161	
	0.013273796	0.015317406	
High	0.988148148	0.993404861	
	0.020343898	0.013992291	

34/66

Contention	1st	2nd	Auction Format
Low	0.967363687	0.972861878	
	0.023369486	0.023434986	
High	0.969537233	0.971342005	
	0.033728847	0.027125329	

80/20

Contention	1st	2nd	Auction Format
Low	0.995208606	0.995526473	
	0.00750111	0.00739069	
High	0.993706601	0.998863636	
	0.011140481	0.005016396	

50/50

Contention	1st	2nd	Auction Format
Low	0.973360891	0.978479276	
	0.026366621	0.022677754	
High	0.980403772	0.984663121	
	0.02854137	0.018166006	

90/10

Contention	1st	2nd	Auction Format
Low	0.999716312	1	
	0.001944867	2.92283E-12	
High	0.998611111	1	
	0.005240602	1.8647E-12	

Figure 1.1. Fitness Score

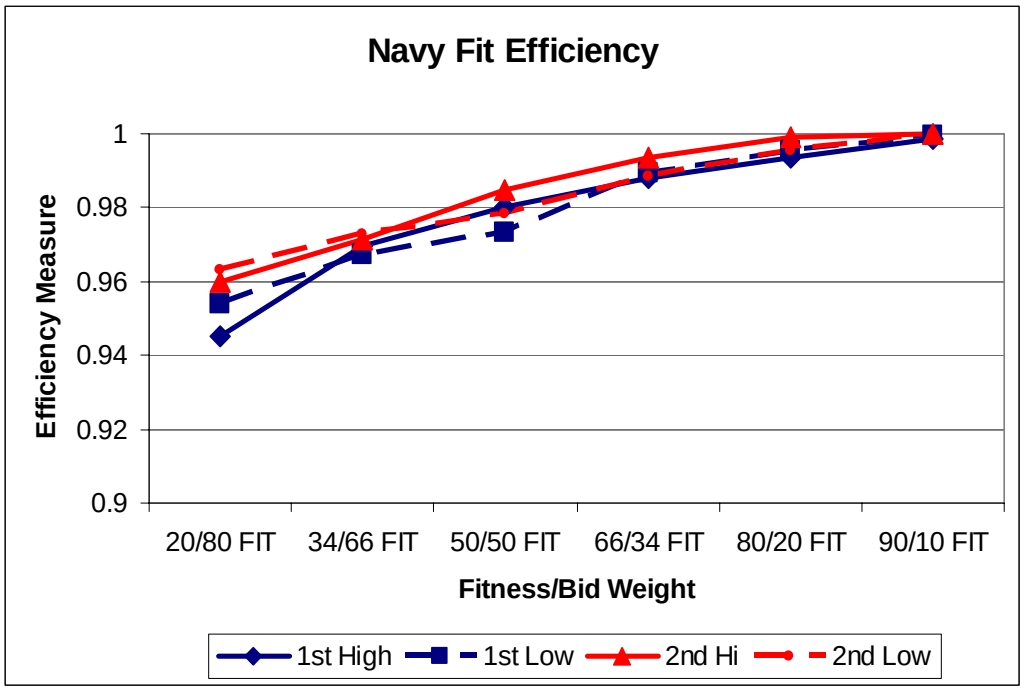

Figure 1.2. Above illustrates the extent to which Sailors are qualified for the billets to which they are assigned by the auction mechanism in force.

2. Wage Bill

The dominant trend seems to be that Wage Bill efficiency increases from 2nd to 1st price auctions across all weights except for F66/B34 where 2nd price high contention outperformed 1st price high contention. It also important to note that all 2nd price high contention auctions have high standard deviations indicating that Wage Bill outcomes vary significantly throughout the experiment. As a result, 1st price high contention across any weight seems to be the optimal choice.

All else equal, a low efficiency value of WB is bad from the Navy's standpoint. It is an indication of a higher premium the Navy must pay to fill a particular billet. This is essential to understand when comparing other performance measures. Figure 2.1 below, indicates that under the 1st price high contention auction WB is lower than other formats. This is interesting because traditionally participants should bid their reservation wage in a 2nd price auction. However, later results show this not to be the case.

WB

20/80

Contention	1st	2nd	Auction Format
Low	0.67815842	0.650098435	
	0.089770733	0.075335626	
High	0.74624817	0.620424754	
	0.089770733	0.099835619	

66/34

Contention	1st	2nd	Auction Format
Low	0.574137822	0.488211134	
	0.088510937	0.049021166	
High	0.683345996	0.751321127	
	0.067628718	0.114430061	

34/66

Contention	1st	2nd	Auction Format
Low	0.752624852	0.583577816	
	0.077859958	0.086385579	
High	0.807915132	0.734893491	
	0.100659912	0.10375679	

80/20

Contention	1st	2nd	Auction Format
Low	0.614811825	0.485031339	
	0.060885109	0.068849186	
High	0.592927888	0.509524058	
	0.078101712	0.129811729	

50/50

Contention	1st	2nd	Auction Format
Low	0.632624501	0.498516235	
	0.064193095	0.095996323	
High	0.695907837	0.613204789	
	0.104193919	0.112583691	

90/10

Contention	1st	2nd	Auction Format
Low	0.460264164	0.369874755	
	0.056826515	0.063392137	
High	0.507702614	0.425885017	
	0.106238159	0.105623748	

Figure 2.1. Wage Bill

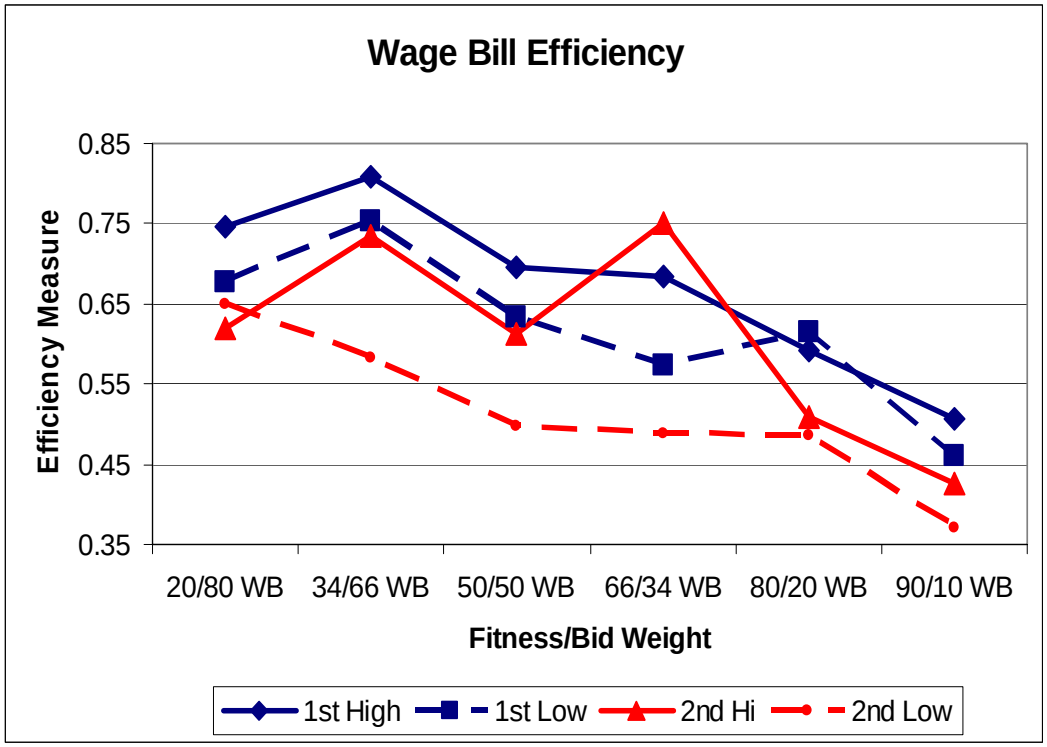

Figure 2.2. Above illustrates the minimum-cost voluntary-participation total wage bill described.

3. Bid Factor All

Bid Factor increases across all weights from high to low contention with the exception of F20/B80 1st price auction. All weights, contentions, and auction formats have high standard deviations making this a hard variable from which to draw a conclusion. With the exception of F20/B80, 2nd price high contention seems to exhibit the least bid inflation. Under this performance measure values greater than one are most suitable for what it intends to calculate. Figure 3.1 below, supports the proposed "Bid Factor All" definition where the measure of "truthful revelation" is completely accurate. In the auction format used, participants are not being asked to reveal their reservation wage in these auctions but are simply being asked to submit a bid without going below their reservation wage. The bidding behavior of each participant can be drastically different. Each participant may bid at their reservation wage which may not exactly be "truthful" but more of a strategy in order to increase their position for selection.

20/80

Contention	1st	2nd	Auction Format
Low	1.444478498	1.264809283	
	0.080305394	0.096247893	
High	1.396474868	1.37382961	
	0.125254441	0.178857512	

66/34

Contention	1st	2nd	Auction Format
Low	1.634328373	1.644515212	
	0.194548402	0.109368806	
High	1.376459436	0.993759892	
	0.277899047	0.107763949	

34/66

Contention	1st	2nd	Auction Format
Low	1.402723438	1.458453515	
	0.130680914	0.20769989	
High	1.153972663	1.102241162	
	0.124912706	0.152769878	

80/20

Contention	1st	2nd	Auction Format
Low	1.516084362	1.543630511	
	0.111934983	0.14615091	
High	1.441958113	1.186202601	
	0.161905549	0.198241403	

50/50

Contention	1st	2nd	Auction Format
Low	1.498791486	1.707696523	
	0.0973209	0.292597982	
High	1.360335464	1.305970752	
	0.089770733	0.154412536	

90/10

Contention	1st	2nd	Auction Format
Low	1.956715355	1.830009921	
	0.112617194	0.131647761	
High	1.809776602	1.313087522	
	0.184094799	0.215832082	

Figure 3.1: Bid Factor All

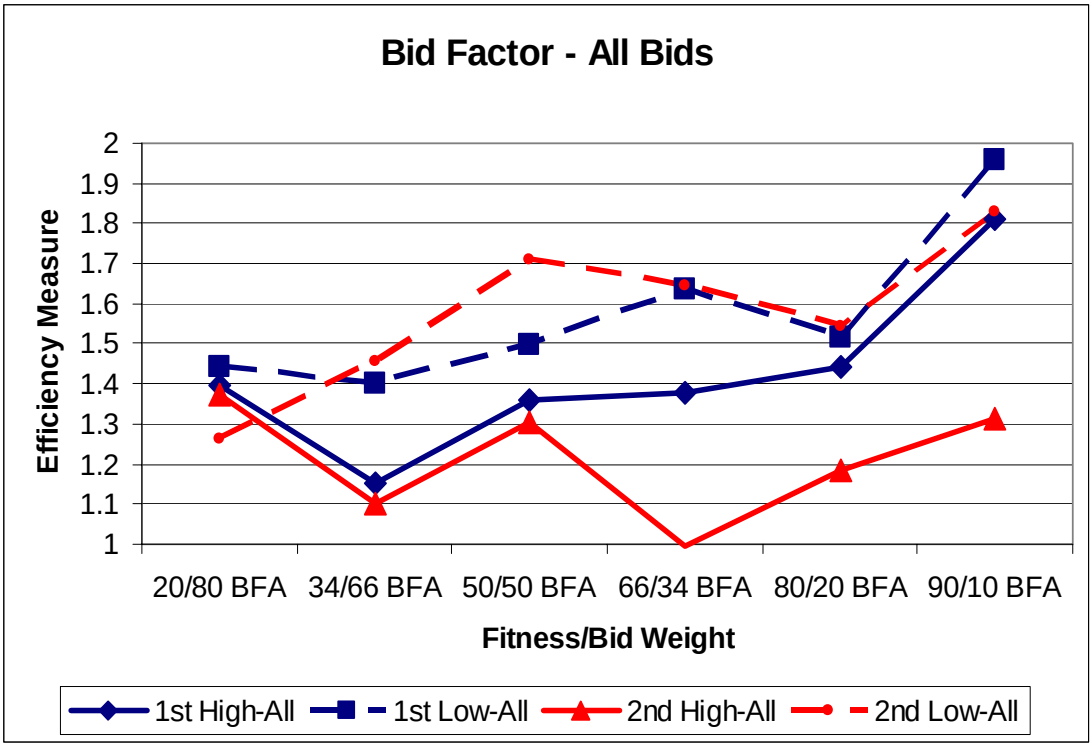

Figure 3.2. Above illustrates the bid inflation relative to true reservation wages.

4. Overall Efficiency

The dominant trend across all weights is that efficiency increases from high to low contention. Also all high contentions across all weights seem to have higher standard deviations than low contentions. High fitness, low bid weights with low contention appears to be the optimal choices for maximizing efficiency.

In order to assess the impact on how small a weight can be placed on a bid before the efficiency of the auction begins to degrade we must optimize the auction data. As indicated in figure 4.1 below, the results clearly indicate that when analyzing first price auction/low contention, the Navy's MOE and Sailor bid are much more efficient. The problem with second price auction is that while more bids are generated per billet there is no guarantee that the Navy could actually repeat the simulated larger pool of participants per available billet.

20/80

Contention	1st	2nd	Auction Format
Low	0.986416389	0.983411961	
	0.011958712	0.017871456	
High	0.683389996	0.692360281	
	0.056348801	0.059707655	

66/34

Contention	1st	2nd	Auction Format
Low	0.990423008	0.990501466	
	0.008245707	0.009367461	
High	0.770089012	0.875767261	
	0.093608355	0.071506187	

34/66

Contention	1st	2nd	Auction Format
Low	0.987940808	0.710220971	
	0.014317522	0.062241708	
High	0.802374063	0.786610927	
	0.050217665	0.066156076	

80/20

Contention	1st	2nd	Auction Format
Low	0.994126262	0.990720968	
	0.0054582	0.007885964	
High	0.77686694	0.839610234	
	0.055226009	0.054685731	

50/50

Contention	1st	2nd	Auction Format
Low	0.987805379	0.982997801	
	0.013633818	0.013284818	
High	0.769029666	0.767559708	
	0.081475254	0.053139311	

90/10

Contention	1st	2nd	Auction Format
Low	0.997687584	0.997316195	
	0.002566131	0.003115958	
High	0.688101018	0.846548521	
	0.043953693	0.075850121	

Figure 4.1. Overall Efficiency

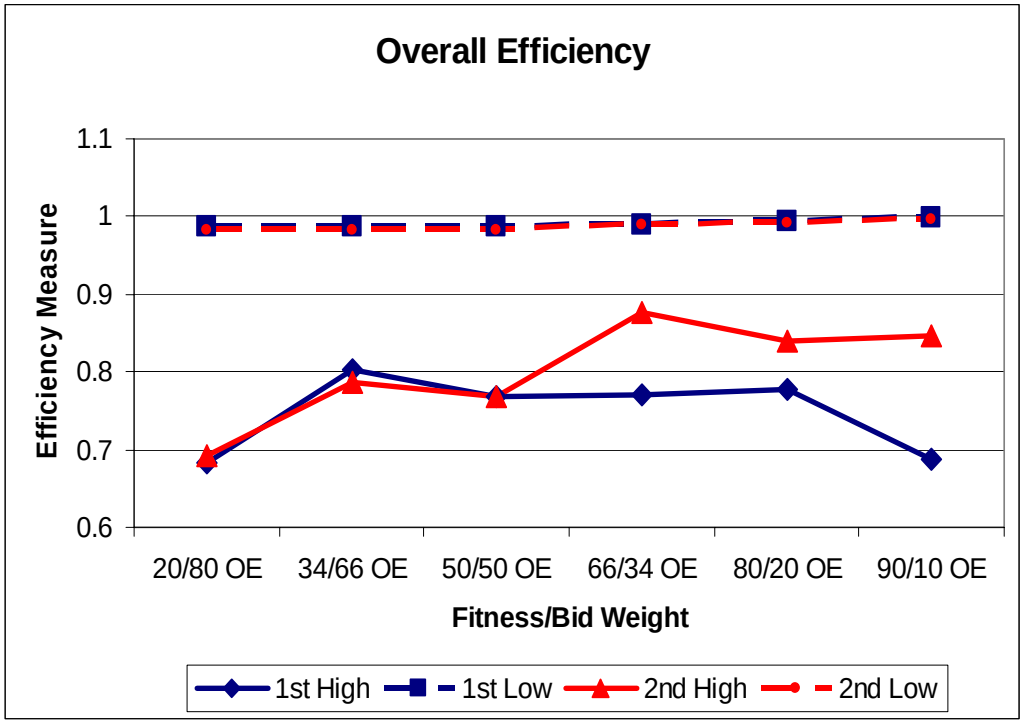

Figure 4.2. Above illustrates the extent to which a particular mechanism achieves the 'ideal' value of the objective function.

J. CONCLUSION

This paper has presented the affects of bid weight versus high/low contention and $1^{st}/2^{nd}$ price auctions in an attempt to find levels of optimization for each variable to improve the quality of auctions for the purposes of Assignment Incentive Pay. In virtually all aspects, 1^{st} price auctions appear to be the most optimal, from the Navy's perspective.

The results clearly indicate that the Navy should not pursue second price auction and engage in a first price/low contention auction approach. Wage Bill is clearly optimized in a 1^{st} price auction and although there are certain weights for which Fitness is optimized in 2^{nd} price auction, by in large Fitness has no clear optimal auction choice over the other and therefore it can be assessed that a high fitness level will be maintained regardless of auction type selected. The "inefficiency" in bidding behavior displayed in Wage Bill contributes to low efficiency measures displayed in Bid Factor All for all high contentions. The Wage Bill results are interesting because they show that given rational parameters, some participants will still act irrationally. Furthermore, Overall Efficiency

displayed high efficiency for all low contentions which gives a strong indication that sufficient billets should be available to allow the auction mechanism many billet options when making assignments.

Additionally, there are other considerations that must be taken into account. There are "a number of evaluation criteria used to analyze auctions and other economic mechanisms."[18] The auction process end result should come together in an equilibrium (i.e. a solution in which neither the bidder nor seller wishes to change its position). Auction design must also consider the speed of reaching this equilibrium and ensure auction stability.

Auction stability ensures that no subset of agents could have done better by coming to an agreement outside of the auction. Although all these criteria are important for the design of the auction process "the key criterion for the winner determination is, however, whether the solution to an allocation shows allocative efficiency."[19] Specifically, the rearrangement of resources could make someone better off without making someone else worse off. Furthermore, the Navy must determine its breakeven point at which the cost of auction assignment to voluntary assignment exceeds the benefits. It must determine the maximum amount of monetary incentive in comparison to its utility (this should include all enlisted ratings). What's more, the Navy must address the cost effectiveness of outsourcing shore duty billets which will vary by billet and location. Finally, the Navy must determine its ultimate goal (i.e. fill rates comparable to all locations, best sailor for the command, lowest bid, application activity, maximum allowable incentive per billet or location, etc.). Answers to these questions are beyond the scope of this project, and we believe that they warrant further study.

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[18] M. Bichler, *The Future of eMarkets: Multi-Dimensional Market Mechanisms.* Cambridge, UK: Cambridge University Press, 2001 (pg 73)

[19] M. Bichler, J. Kalagnanam, H. S. Lee and J. Lee, *Winner Determination Algorithms for Electronic Auctions: A Framework Design.* IBM T.J. Watson Research Center, IBM Systems Journal 2002.

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APPENDIX A.. THE DESIGN OF EXPERIMENTS TO MEASURE AND ASSESS THE EFFICIENCY OF ALTERNATIVE ASSIGNMENT AUCTION FORMATS

II. Auction Format

A single experiment, which might take 60-90 minutes to complete, would consist of six subjects competing in a series of 20 auctions for either four or five available billets. Depending on the bids submitted and the rules of the auction, "winning bidders" are determined and assigned to available billets and paid accordingly. "Losing bidders" are awarded no billet and no pay (which represents burdensome downtime on the part of Sailors). There would be either four or five winning bidders, and one or two losing bidders each auction.

Reservation Wages and Fitness Scores

The 20 auctions within one experiment are conducted in succession, but independently of each other. At the beginning of every auction, each subject is informed of his "type" for that auction. A Sailor's type consists of his reservation wages (willingness to accept the respective billets) and fitness scores (qualifications for the respective billets). Each subject's type is determined by random selection each auction from a predetermined set of reservations wages and fitness values—and this procedure is common knowledge among all subjects. The pre-determined reservation wages are represented by a 10x5 matrix of values, **C**, where columns represent the separate billets on offer (the fifth column would be suppressed in experiments where only four billets are available), and rows represent different sets of preferences regarding those billets.

$$\mathbf{C} = \begin{bmatrix} C_{1,1} & \cdots & C_{1,5} \\ \vdots & \ddots & \vdots \\ C_{10,1} & \cdots & C_{10,5} \end{bmatrix}$$

Thus, at the beginning of an auction, each subject is informed of his preferences, which correspond to a row selected at random (with replacement) from this matrix. Each subject is informed only of his own type, not the specific types assigned to others. However, all subjects know that the types of their rivals are drawn randomly from this same matrix. It would be advisable to present this matrix to the subjects, accompanied by the average of the ten possible values for each billet, which would allow each subject to quickly gauge how they might compare to their rivals:

$$\mathbf{C} = \begin{bmatrix} C_{1,1} & \cdots & C_{1,5} \\ \vdots & \ddots & \vdots \\ C_{10,1} & \cdots & C_{10,5} \\ \hline C_{avg,1} & \cdots & C_{avg,5} \end{bmatrix}$$

The reservation wages actually assigned to respective subjects over all 20 auctions can be represented by a 6x5x20 array: $\mathbf{c} = \{c_{i,j,k}\}$, where i denotes the subject, j the billet, and k the auction. The entries in this matrix are determined once and for all, before any experiments are conducted, and then used over again in each experiment to impose the same design on each experiment. The auction mechanism will vary between experiments, but this design matrix of subjects' reservation wages will not.

The pre-determined fitness scores are represented by a similar 3x5 matrix of values, **F**, where columns represent the several billets on offer (the fifth column would be suppressed in experiments where only four billets are available), and rows represent subjects' differing abilities (qualifications) to fill those billets.

$$\mathbf{F} = \begin{bmatrix} F_{1,1} & \cdots & F_{1,5} \\ \vdots & \ddots & \vdots \\ F_{3,1} & \cdots & F_{3,5} \end{bmatrix}$$

Thus, at the beginning of an auction, each subject is informed of his qualifications, which correspond to a row selected at random (with replacement) from this matrix. Each subject is informed only of his own qualifications, not the specific qualifications assigned to others. However, all subjects know that the qualifications of their rivals are drawn randomly from this same matrix. It would be advisable to present this matrix to the subjects, accompanied by the average of the three possible values for each billet, which would allow each subject to quickly gauge how their qualifications might compare to their rivals:

$$\mathbf{F} = \left[\begin{array}{ccc} F_{1,1} & \cdots & F_{1,5} \\ \vdots & \ddots & \vdots \\ F_{3,1} & \cdots & F_{3,5} \\ \hline F_{avg,1} & \cdots & F_{avg,5} \end{array}\right]$$

The fitness scores actually assigned to respective subjects over all 20 auctions can be represented by a 6x5x20 array: $\mathbf{f} = \{f_{i,j,k}\}$, where i denotes the subject, j the billet, and k the auction. The entries in this matrix are determined once and for all, before any experiments are conducted, and then used over again in each experiment to impose the same design on each experiment. The auction mechanism will vary between experiments, but this design matrix of subjects' fitness scores will not.

The elements of matrices **C** and **F** are to be determined by a procedure that controls the correlation between rows within each matrix. This permits the experimenter to govern the degree of similarity among Sailors. Moreover, the variance of the $\{C_{ij}\}$ and $\{F_{ij}\}$ within columns (for each billet) should be of comparable magnitude (which will help to ensure that variations in both components of a Sailor's combined score will be influential in the outcome of the auction).

Bidding Caps and Floors

The Navy's standard pay offer, s_{min}, constitutes the minimum bid that any subject may submit for any billet, and this value is chosen by the experimenter and made known to all subjects at the outset of an experiment. The standard pay level is not varied between auctions of an experiment or across billets. A decision for the experimenter is whether to set the standard pay level above the minimum of the $\{C_{ij}\}$, in which case subjects would be prevented from bidding truthfully on those occasions when their assigned reservation wages are relatively low.

The Navy's bid cap, s_{max}, is the most any subject may bid for any billet, and this value is chosen by the experimenter and made known to all subjects at the outset of an experiment. Like the standard pay level, the bid cap is not varied between auctions of an experiment or across billets. If the bid cap is set below the maximum of the $\{C_{ij}\}$, subjects would be prevented from bidding truthfully on those occasions when their assigned reservation wages are relatively high.

The degree of inefficiency that potentially comes from caps and floors could be explored by conducting some experiments without the caps and floors in force, and comparing results to experiments where binding floors and caps are in force. Particular values of the caps and floors should not be set until values of the **C**, **F**, **c**, and **f** matrices have been determined.

III. Auction Mechanisms

The auction mechanism, which is fixed throughout the 20 auctions of an experiment, consists of the rules that determine: (1) the assignment of subjects to billets, and (2) the pay awarded to each subject for the given assignment.

Bids, Fitness Scores, and Aggregate Scores:

In all experiments, subjects are directed to submit bids for each of the available billets. The bids submitted in a given experiment can be represented by $\{b_{ijk}\}$, which represents the bid of subject i for billet j in auction k of the experiment. A subject's "aggregate score" for each billet will be denoted by z_{ijk}, and is computed as a linear combination of his bid and fitness score, according to the formula:

$$z_{ijk} = 100\alpha\left(1 - b_{ijk} / s_{\max}\right) + \left(1-\alpha\right) f_{ijk}.$$

Notice that bidding high relative to the maximum allowable bid tends to reduce the aggregate score; i.e., lower bids enhance the aggregate score just as higher fitness scores do. The value of parameter α controls the relative weight assigned to the two components of the aggregate score. If the experimenter sets $\alpha = 1/(1+100/s_{max})$, then a one dollar reduction in bid has the same impact as one unit increase in fitness score.[1] If the range over which reservation prices vary among subjects is the same as the range over

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[1] This is determined by partial differentiation: $-\frac{\partial z_{ijk}}{\partial b_{ijk}} = 100\alpha / s_{\max}$, and: $\frac{\partial z_{ijk}}{\partial f_{ijk}} = 1-\alpha$. Equating these two partial derivatives and solving for α yields: $\alpha = \frac{1}{1+100/s_{\max}}$. For example, if the maximum allowable bid is given by $s_{max} = 400$, then a weight of $\alpha = 1/(1+¼) = 80\%$ must be attached to the bid component in order to make its influence on the aggregate score equal to that of the fitness score.

which fitness scores vary, then money bids and fitness scores will carry roughly equal weight in determining the outcome of the auction—assuming that Sailors bid truthfully. As noted previously, the values of matrices **C** and **F** and parameter α should be determined with this in mind.

Determining the Assignment:

The same criterion for assigning subjects to billets is used in all experiments; this part of the mechanism does not change. The criterion is simply to obtain the highest total of aggregate scores *each auction*, when summed across the available billets:

$$\max: Z_k = \sum_{i=1}^{6}\sum_{j=1}^{J} z_{ijk} x_{ijk} ,$$

where k represents the given auction, and $x_{ijk} = 1$ if subject i is assigned to billet j in auction k, otherwise $x_{ijk} = 0$. The constraints are that no Sailor can be assigned to more than one billet, no billet can have more than one Sailor assigned to it, and Sailors who are unassigned are "left out" of the solution (awarded no billet and no pay for that auction).

The "efficient outcome" of the auction provides a performance benchmark and is defined to be the assignment that maximizes the following objective function:

$$\max: Z_k^* = \sum_{i=1}^{6}\sum_{j=1}^{J} z_{ijk}^* x_{ijk}^* ,$$

where $z_{ijk}^* = 100\alpha\left(1 - c_{ijk} / s_{\max}\right) + (1-\alpha) f_{ijk}$. This assignment differs from the actual assignment only in that the actual bids have been replaced by the subjects' true reservation wages, c_{ijk}. Notice that since the z_{ijk}^* do not vary from experiment to experiment, neither do the efficient outcomes vary from experiment to experiment.

These calculations need to be performed only once and then reused each experiment, whereas the actual assignments must be calculated fresh in each experiment according to the bids that are submitted.

Determining Pay Levels:

First-Price Mechanism: Under the first-price mechanism, each subject who is assigned to a billet is paid for that auction the actual amount of his bid for the assigned billet. Actual pay levels, s_{ijk}, for the respective subjects and billets in any auction can therefore be computed as:

$$s_{ijk} = b_{ijk} x_{ijk}$$

Note: because the assignment is made on the basis of the z_{ijk}, rather than the money bids alone, it is possible that the winner of a particular billet will not have tendered the lowest money bid. Under the first price mechanism, this has no impact on the actual pay level awarded to that subject, who receives the full amount of his bid regardless of whether it was the lowest.

From the subject's perspective, the net reward (r_{ijk}) earned from participation in the auction is given by the excess of actual pay over his reservation price for the assigned billet: $r_{ijk} = (b_{ijk} - c_{ijk}) x_{ijk}$.

Second-Price Mechanism: Under the second-price mechanism, each subject who is assigned to a billet is paid for that auction an amount equal to the next higher money bid for that billet (if one exists), or s_{max}—whichever is lower. Thus, given that a subject is assigned to a billet, his pay cannot be lower than the amount he bids, but could be higher. Bidding higher does not tend to raise the amount a subject would receive because

his pay level will be determined by the bids of others. On the contrary, bidding higher tends to reduce the amount a subject receives due to the greater probability that a high bid would cause the subject to remain unassigned.

Regarding the pay of unassigned Sailors, awarding them zero reward, s_{ijk}=0, already serves as a penalty sorts, compared to the reward they might have earned through assignment. However, it could be useful to further penalize the net reward offered to Sailors who are left unassigned. This is because, under the FP mechanism, any Sailor who bids truthfully (i.e., b_{ijk}=c_{ijk}) and is assigned a billet would also receive a net reward of zero. (But note that truthful bidding is not rational behavior under the FP mechanism!) If this is a concern, the penalty for remaining unassigned could be elevated in the experiment by awarding all assigned Sailors some additional fixed amount of actual pay (assignment bonus) that is denied to unassigned Sailors.

IV. Measures of Auction Effectiveness

A variety of measures are needed to appraise the performance of a given auction mechanism. After each experiment has been completed, the following performance criteria can be evaluated:

Consumer Surplus (*CS*):

This index measures, for a given experiment, the extent to which subjects are paid more than their reservation wages for the billets to which they are assigned. Higher consumer surplus equates to happier Sailors, albeit at a monetary cost to the Navy.

$$CS = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20}\left(s_{ijk} - c_{ijk}\right)x_{ijk}}{CS^*}, \qquad \text{where: } CS^* = \sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20}\left(s^*_{ijk} - c_{ijk}\right)x^*_{ijk}.$$

As is apparent, this formula measures the amount of consumer surplus relative to the consumer surplus that would be obtained at the efficient outcome (where the assignment and pay levels are recomputed after replacing bids with true reservation prices). The pay levels denoted by s_{ijk} and s^*_{ijk} are determined according to the rules of the mechanism in effect for the given experiment. Alternative benchmarks could be computed by replacing the denominator with other standards of comparison. For example, to get a sense of how much the particular weighting factor (α) affects auction performance, CS^* might be computed for the two polar cases defined by $\alpha = 0$ (no weight given to Sailor preferences) and $\alpha = 1$ (no weight given to fitness scores). These variations would indicate the relative "cost" or loss of performance that is caused by placing more or less weight on preferences vs. qualifications.

Note: the shadow prices of the Vickrey-Leonard auction are not involved in this formula, but the denominator could be defined in terms of those prices as well, and the Vickrey-Leonard benchmark could be used either in addition to, or instead of, the wages determined by the actual mechanism in force.

Total Wage Bill (WB):

This index measures, for a given experiment, the Navy's total monetary cost of filling the available billets.

$$WB = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} s_{ijk}x_{ijk}}{WB^*}.$$

The denominator is construed as in the previous case (CS) and again provides a benchmark.

Total Labor Cost (*LC*):

This index measures, for a given experiment, the total burden placed on Sailors (regardless of how well they are compensated for it) taking into account only their preferences among alternative assignments.

$$LC = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} c_{ijk} x_{ijk}}{LC^*}.$$

Total Fitness Level (*TF*):

This index measures, for a given experiment, the extent to which Sailors are qualified for the billets to which they are assigned by the auction mechanism in force.

$$TF = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} f_{ijk} x_{ijk}}{TF^*}.$$

Overall Efficiency (OE):

This index measures, for a given experiment, the extent to which a particular mechanism achieves the "ideal" value of the objective function. If Sailors do bid truthfully under a given mechanism, then the efficient outcome will be achieved and the index will take on the value 1.

$$OE = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} z_{ijk} x_{ijk}}{OE^*}.$$

Bidding Factor (*BF*):

This is an indicator of systematic deviations from truthful revelation in bidding strategies. For a given experiment, it can be computed as a simple average as follows:

$$BF = \frac{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} b_{ijk}}{\sum_{i=1}^{6}\sum_{j=1}^{J}\sum_{k=1}^{20} c_{ijk}},$$

or by plotting bids versus reservation prices and fitness scores for each experiment and computing the least squares regression line:

$$b_{ijk} = \hat{\beta}_o + \hat{\beta}_1 c_{ijk} + \hat{\beta}_2 f_{ijk} + e_{ijk},$$

where the estimated parameters $\left(\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2\right)$ define the bidding function, and the e_{ijk} represent the fitted errors relative to the estimated bidding function. Truthful disclosure would be represented by $BF = 1$; or by $\hat{\beta}_0 = \hat{\beta}_2 = 0$ and $\hat{\beta}_1 = 1$.

Mechanisms that vary significantly in terms of truthful disclosure would be expected to vary in terms of other performance measures, as well.

V. Proposed Regime of Experiments/Treatments

A complete factorial design that fully interacts all possible variables may be impractical—especially since two separate experiments of each treatment combination are recommended to ensure the validity of statistical results. Nonetheless, here follows a relatively comprehensive schedule of experiments that would afford a reasonable first examination of the impact of variations in auction design on performance.

Regarding bidding caps and floors, the following values are recommended for all experiments: $s_{min} = 0$ and $s_{max} = \max\{C_{ij}\}$, i.e., the cap is set at the highest possible reservation wage of any Sailor. This set of caps and floors constrains behavior in a meaningful way but does not interfere with any subject's ability to bid truthfully, if desired.

Proposed Experimental Regime

Experiment	Mechanism	Balance*	Contention**
1	FP	1/3	Low (6/5)
2	FP	1/3	High (6/4)
3	SP	1/3	Low (6/5)
4	SP	1/3	High (6/4)
5	FP	2/3	Low (6/5)
6	FP	2/3	High (6/4)
7	SP	2/3	Low (6/5)
8	SP	2/3	High (6/4)

*The "balance" refers to relative influence of Sailor bids vs. fitness scores, and is achieved by setting parameter α to put the two partial derivatives (see page 6) in the indicated ratio, either 1:3 or 2:3.

**"Low" contention is achieved by having 6 subjects compete for 5 billets. "High" contention is achieved by having 6 subjects compete for 4 billets.

APPENDIX B. INSTRUCTIONS FOR AUCTION EXPERIMENTS

Introduction

You are about to participate in an experiment in which you will make decisions in an auction. Several auctions will be conducted but the exact number is unknown. You and 5 other participants (6 total) are gathered as candidates to fill 5 fictitious jobs. Whether or not you are selected for a particular job will in part depend on how qualified you are for the job (as expressed by a fitness score randomly generated by the software) and how willing you are to take the job (as expressed by how low your bid is for the job). The greater your bid for a job, the more money you will receive if you are selected for it. On other hand, bidding high for a job makes it less likely that the software will select you for that job. Bidding high on all jobs makes it more likely that you will be unassigned. Being unassigned means that not only do you not earn any money in that auction but you will also incur a penalty of $0.30. Exactly how your bids affect your assignment is explained below. Your task is to select a bid for a series of jobs.

We will first conduct a short experiment that does not involve monetary payouts so that you may first familiarize yourself with the procedure.

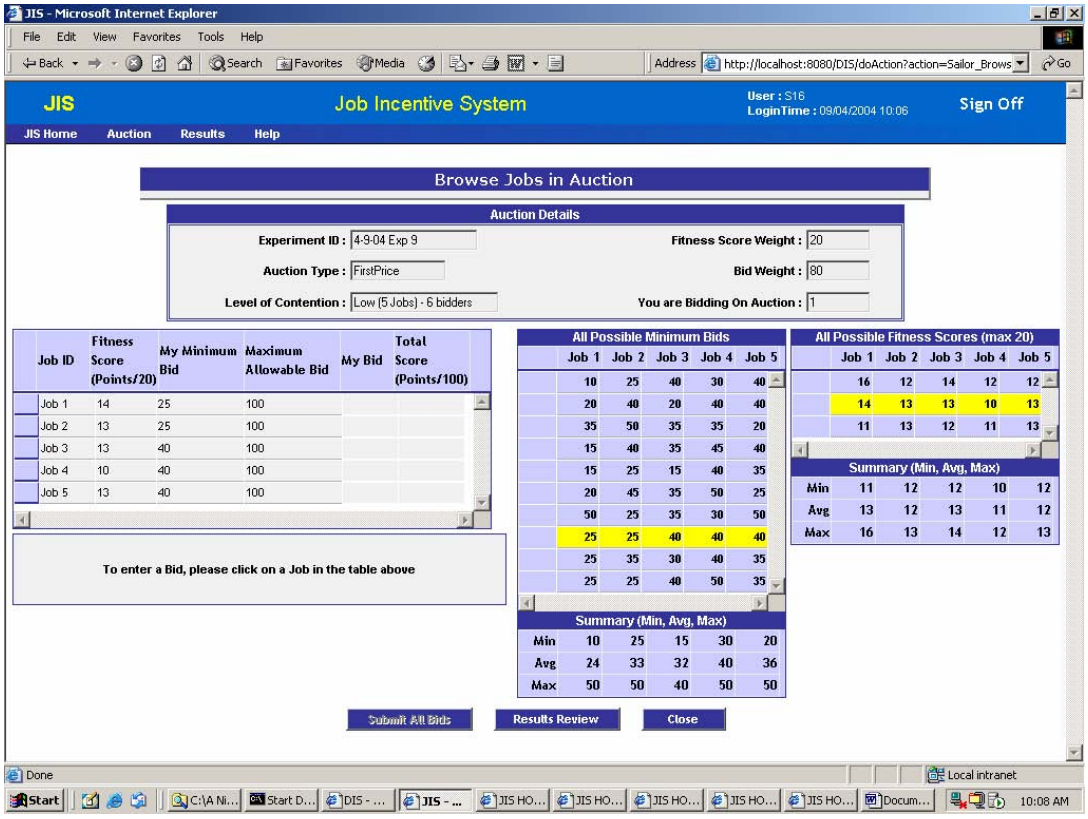
Your bids and profit in these auctions will be in terms of Gamebucks but you can convert them into U.S. Dollars at a rate of U.S. Dollars/Gamebuck = 0.10. In other words, if you were to earn 10 Gamebucks in profit you would earn $1.00 in U.S. Dollars. Any profits earned will be yours to keep.

For your participation today you are guaranteed to leave this room with no less than $13, but you may earn more.

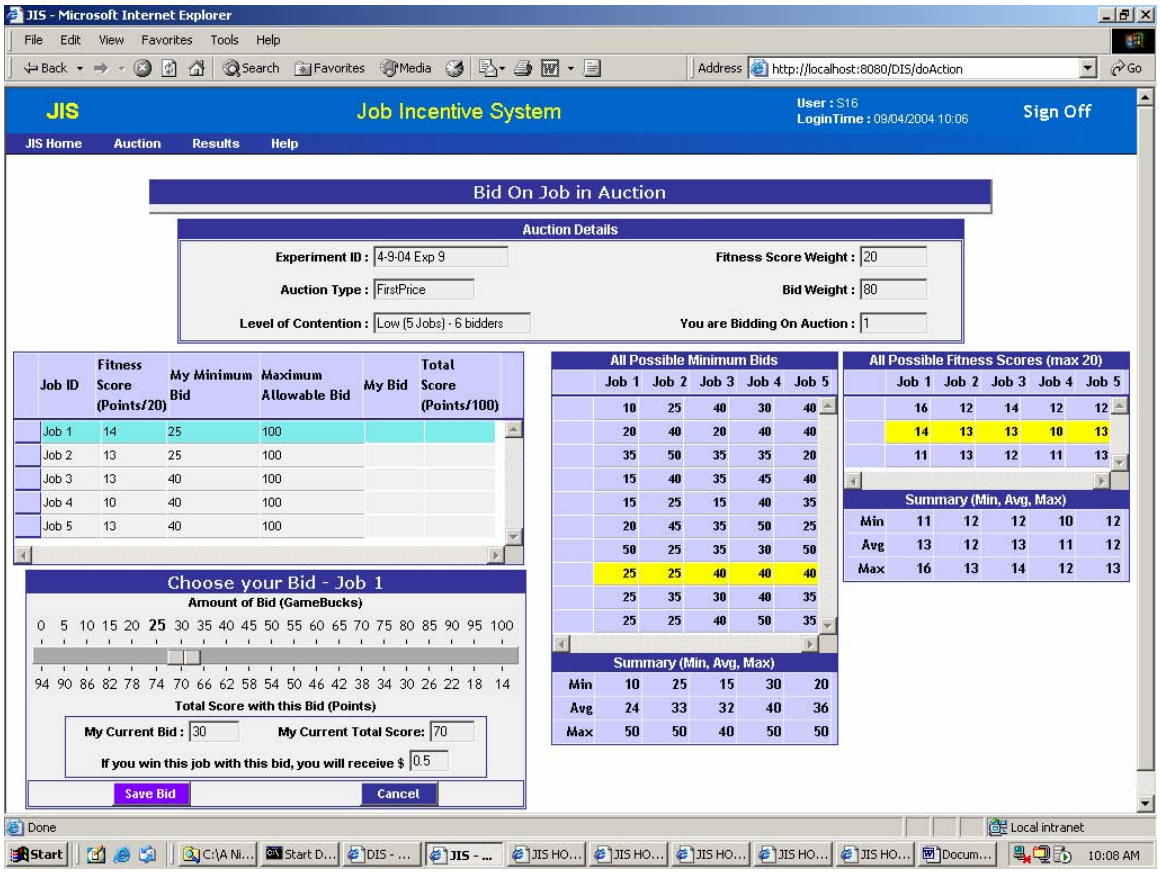
How to Bid on Jobs in the Auction

In the lower left hand box of Screen 1 you will see 5 jobs (i.e. Job 1, Job 2, Job 3, Job 4, and Job 5) on which you will bid. For example, to bid on Job 1 click on the row starting with Job 1. This will cause the bid calculator pop-up to appear as in Screen 2.

Screen 1



Screen 2



Screen 2 displays the same screen as in Screen 1 but now includes the bid calculator pop-up that will assist you in placing your bid for Job 1. As you move the scroll bar to the right, the bottom three boxes will indicate that bid's value in Gamebucks that that position of the scroll bar reflects, the corresponding Total Score (out of 100 possible points) that bid generates, and translate that bid in terms of U.S. Dollars that you would earn if you were to submit that bid and be assigned that job. Once you are satisfied with a particular bid, click on the "Save Bid" button and the pop-up bid calculator will disappear and you may select another job on which to bid. Once you have placed a bid on all the jobs and are satisfied with your bids, click on the "Submit All Bids" button displayed in Screen 1. At this point you must wait until all bids from the participants have been submitted and the results made available.

How Your Bids Affect Your Assignment

In each auction you will be presented with 5 jobs on which you may bid. You will be competing with 5 other bidders (6 total) for these jobs. Your Total Score affects your assignment. The higher your Bid, the lower is your Total Score. In each of the several auctions in which you participate, the weight on your Bid is 80% and the weight on your Fitness Score is 20%. This means that you may receive as many as 80 points for your bid and 20 points for your Fitness Score. The highest value that your Total Score could be is 100 points. If your Bid were 0 Gamebucks, then you will receive all 80 points for the bid component of your Total Score. On the other hand, if your bid were 100 Gamebucks, which is the maximum allowable number of Gamebucks, then you will receive 0 points toward your Total Score. The remaining 20 possible points come from your Fitness Score. You will be randomly assigned a number ranging from 0 to 20 for your Fitness Score for each job. This means that 1/5 of your Total Score is unaffected by your bid. For each auction the software will then make the assignments that generate the maximum possible sum of Total Scores across all assignments. An illustrative example is given at the end.

How Your Payments Are Calculated

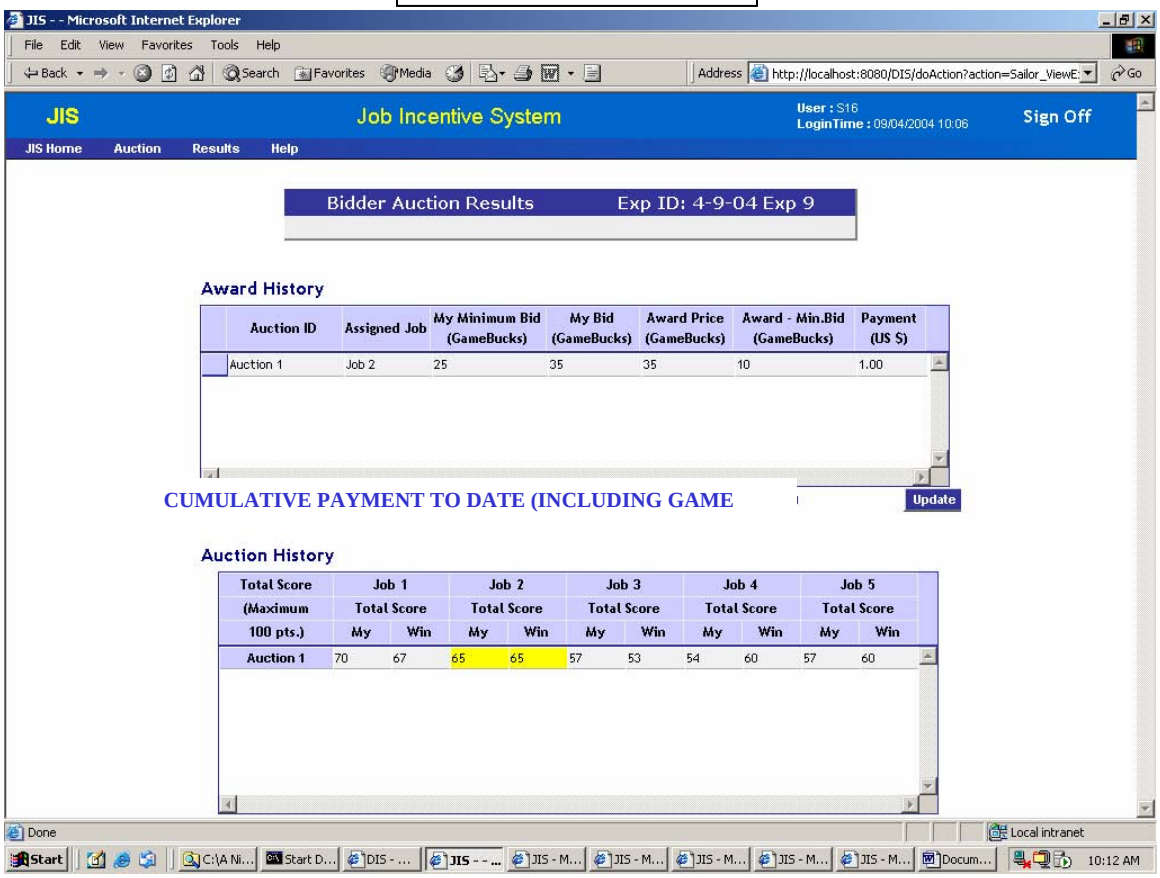
You will receive $15 U.S. Dollars of Game Money that you may think of as "working capital" that you can either add to or lose in the following manner. Note that this $15 is already reflected in the "Cumulative payment to date (including Game Money)" figure tabulated at the end of each auction and displayed as in Screen 3. In the example case given, if all the auctions were completed, then your total payment upon leaving the experiment would be the $16.00 (as indicated on Screen 3).

In each auction the Game Money may be added to or lost in the following manner. Suppose that based on the above calculations you have been assigned to Job 2 as shown in Screen 3. Furthermore, assume that your bid was 35 Gamebucks. Since your "My Minimum Bid" was 25 Gamebucks, that means that your profit is 10 Gamebucks (i.e. 35-25 = 10). You may exchange that profit in Gamebucks for U.S. Dollars at a rate of U.S. Dollar/Gambuck = 0.10. Thus, your earning from that auction is $1.00 (i.e. 0.10

x 10 = 1.00) in U.S. Dollars. As shown in Screen 3, after each auction the software will update your cumulative payment to date (including Game Money) in U.S. Dollars to reflect the outcome of the last auction. On the other hand suppose that you were not assigned any job. In this case $0.30 will be subtracted from your cumulative payment to date figure as tabulated in Screen 3.

Bidding less than your "My Minimum Bid" is highly discouraged in this auction. If you bid below your "My Minimum Bid" this increases the likelihood that you will be assigned that job and if you were assigned that job you will lose money. For instance, if your bid were 20 Gamebucks and "My Minimum Bid" were 40 Gamebucks then you lose 20 Gamebucks or $2.00 U.S. Dollars (i.e. 20x0.10 = 2.00). In this case $2.00 (U.S. Dollars) is subtracted from your cumulative payment to date figure.

Screen 3



Information Provided to Inform Your Bids

On the right hand side of both Screens 1 and 2 for each of the 5 jobs you will see a table titled "All Possible Minimum Bids." This table indicates that for the 5 jobs in this auction there are 10 rows from which one row is randomly selected (with replacement) for each bidder. The row highlighted is the one randomly selected for you for this auction. In subsequent auctions another random selection will be made for you. Although you do not know the row that is selected for your competitors, you do know all the possible rows from which they are randomly drawn. Furthermore, for each job you know whether or not your "My Minimum Bid" is above or below the average of all possible values. For instance, you know that for Job 1, your "My Minimum Bid" is 25, which is slightly greater than the average of 24.

Similarly, on the right hand side of both Screens 1 and 2 for each of the 5 jobs you will see a table titled "All Possible Fitness Scores (max 20)." Recall that the Fitness Score contributes to your Total Score as well. Your randomly selected (with replacement) row is highlighted in yellow. Other bidders will also be given a randomly selected a row for their Fitness Scores. The other bidders' rows may be different than yours. Again, the averages for each job are presented at the bottom so that you have some idea whether your Fitness Score is likely to be better or worse than the average.

You may want to refer to this information when determining how to set your bids for each of the available jobs. From this information you may be able to draw some inferences about what your competitors' bids are likely to be. Since other participants' bids affect your assignment, this information may be helpful, but you are not required to refer to it when determining your bids.

How Assignments are Determined – A Simple Example

To illustrate how the software will select who is assigned to a particular job, and

Table 1

	Job 1	Job 2
Bidder 1's Total Score	60	62
Bidder 2's Total Score	50	50
Bidder 3's Total Score	30	55

who is not assigned at all, let's take a simple 2-job, 3-bidder scenario. The below Table 1 indicates the 2 Total Scores for each of the 3 bidders. Given that there are 3 bidders and 2 jobs, there are 6 possible ways to determine the Assignment Set. The software calculates the Sum of the Total Scores for all 6 possible sets of assignments and then picks the one with the largest Sum of the Total Scores. No bidder will be assigned to more than one job per auction. In case of a tie the Assignment Set is randomly selected from those that offer the largest Sum of the Total Scores.

Table 2

Assignment Set		Job 1 Total Score		Job 2 Total Score		Sum of the Total Scores
1	Bidder 1	60	Bidder 2	50	60+50 =	110
2	Bidder 1	60	Bidder 3	55	60+55 =	115
3	Bidder 2	50	Bidder 1	62	50+62 =	112
4	Bidder 2	50	Bidder 3	55	50+55 =	105
5	Bidder 3	30	Bidder 1	62	30+62 =	92
6	Bidder 3	30	Bidder 2	50	30+50 =	80

Table 2 displays the Sum of the Total Scores for all Assignment Sets and highlights Assignment Set 2 as that is the one that generates the largest Sum of the Total Scores (60 + 55 = 115). Accordingly, Bidder 1 is assigned to Job 1, Bidder 2 is unassigned, and Bidder 3 is assigned to Job 2.

Payout in the Event of a Major Software Malfunction

This software has been tested extensively but in the event of a software malfunction that precludes the determination of the your proper payout, then you will be given $30 for your participation. The determination of whether there has been a major software malfunction will be made by the experiment administrators.

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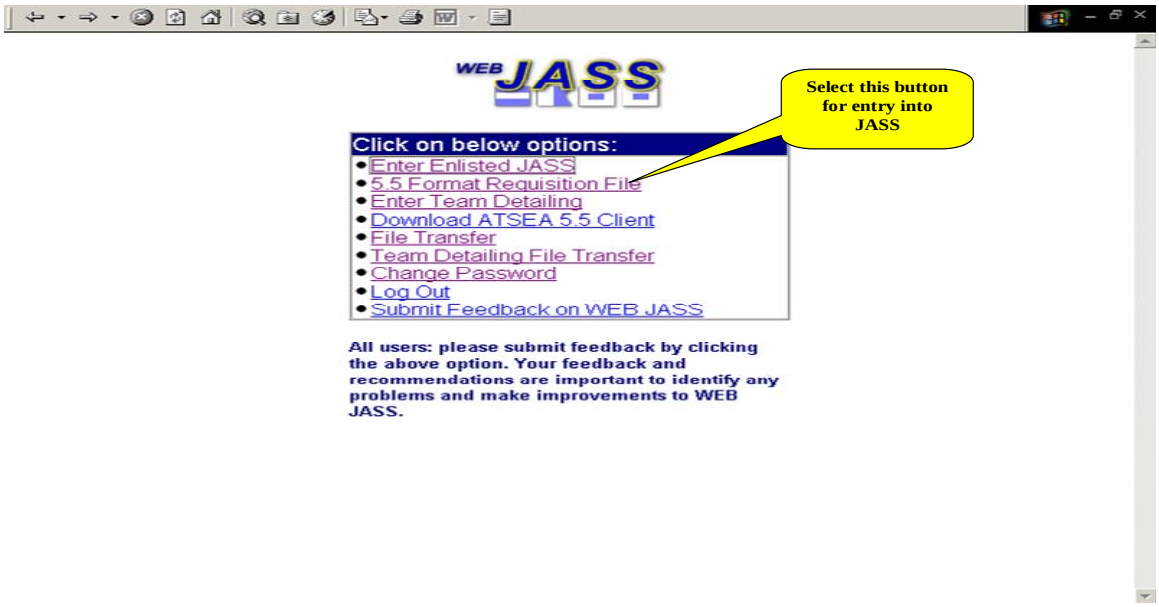
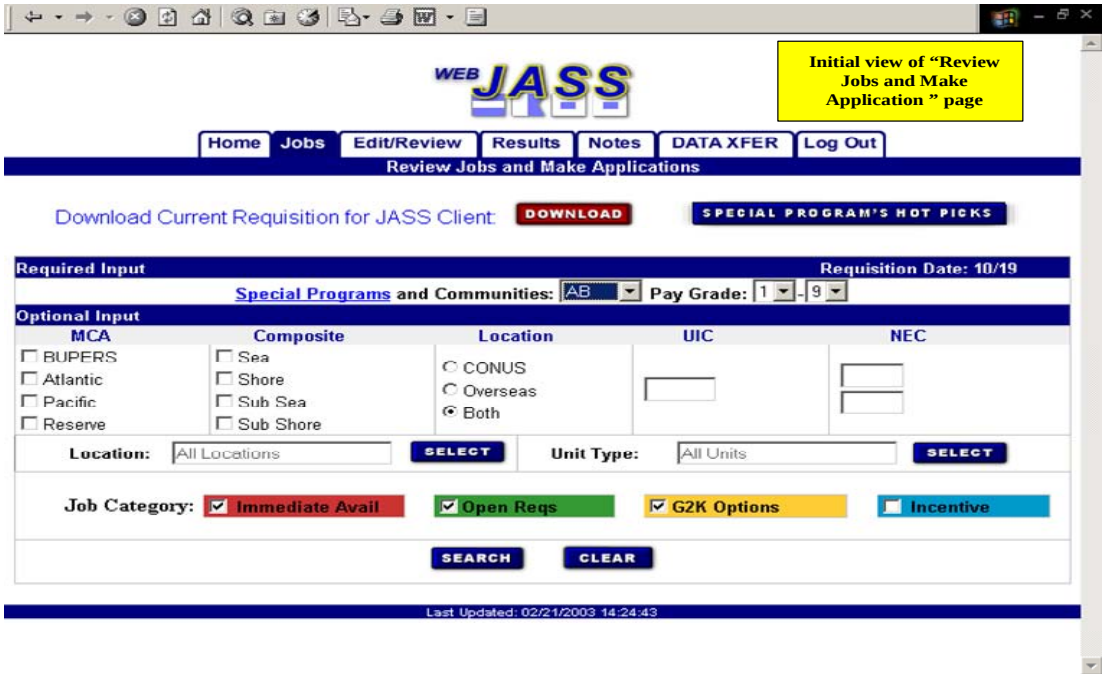
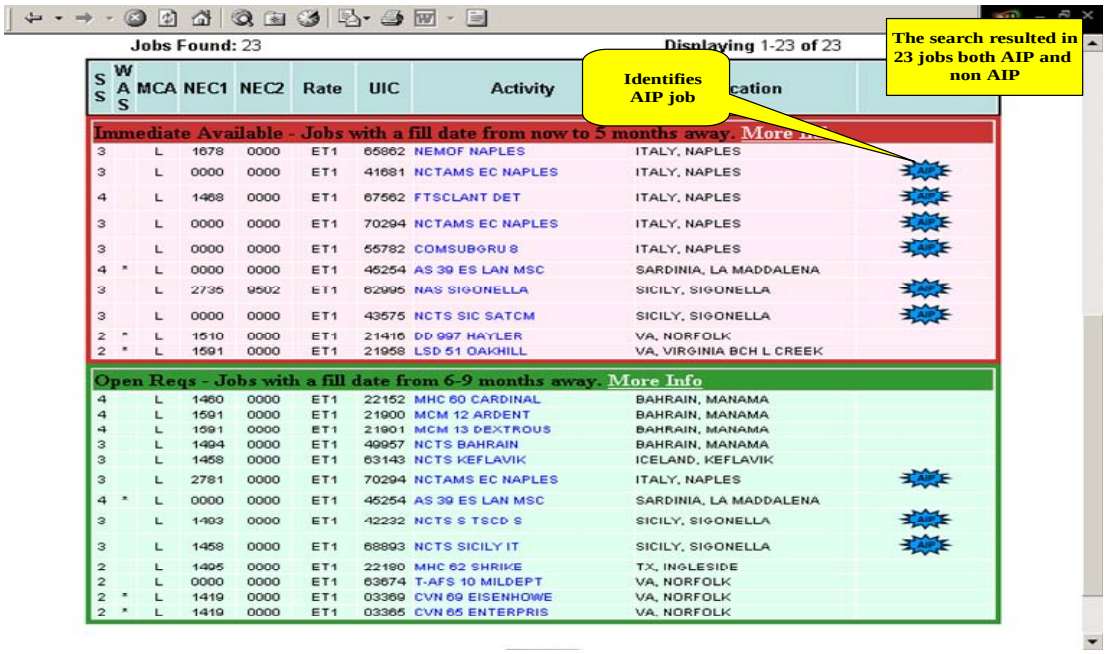
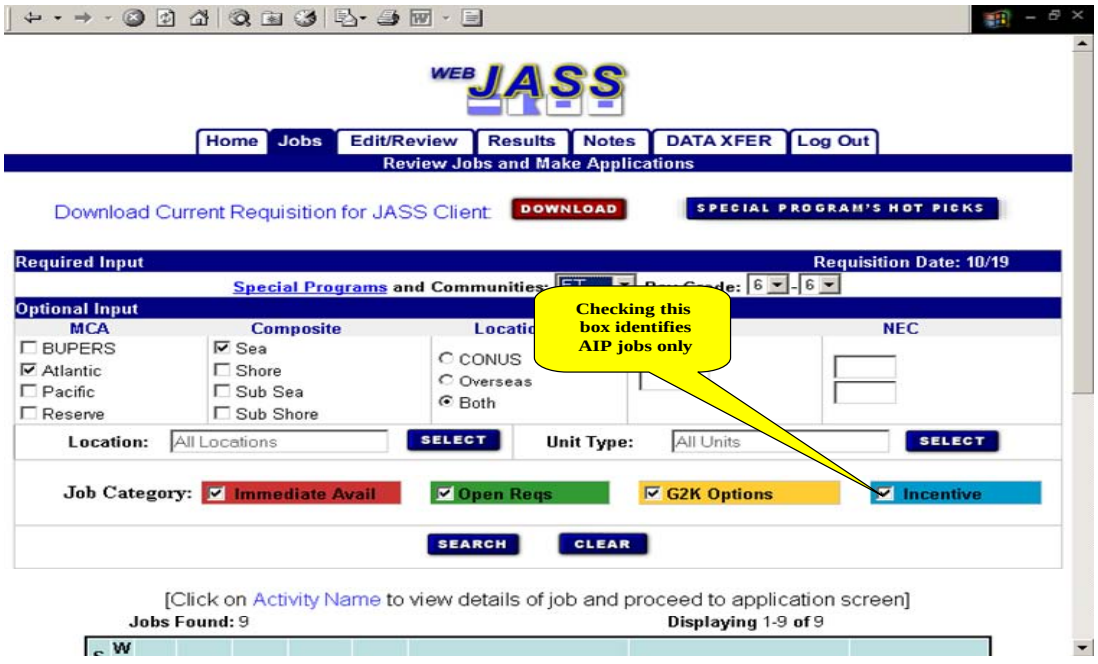
APPENDIX C. JASS DISPLAYS OF AIP

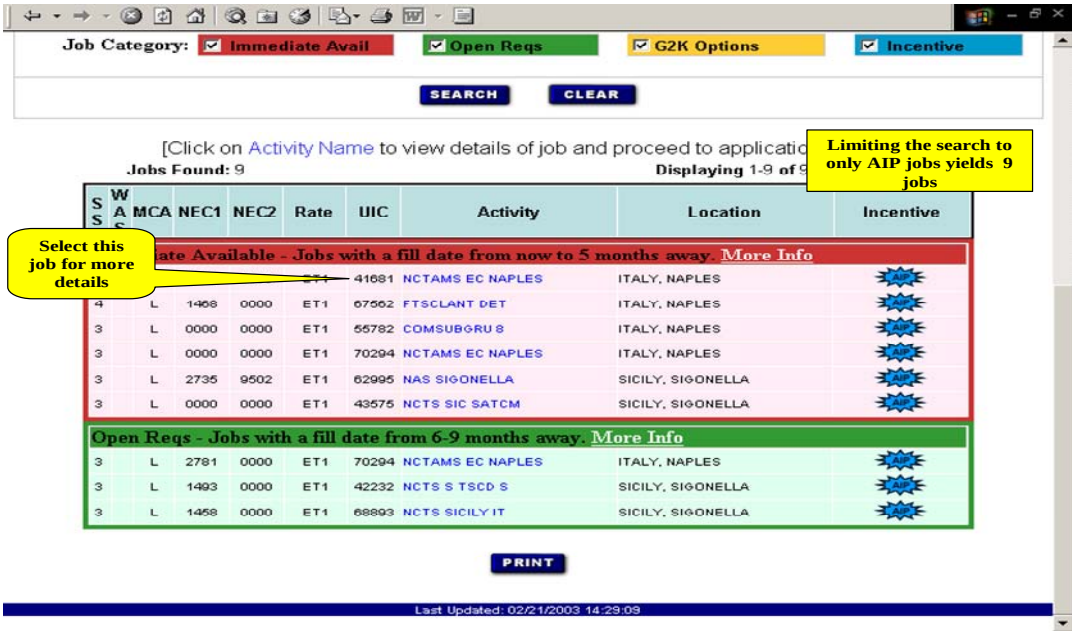
JASS Displays of AIP






Jobs Found: 23
Displaying 1-23 of 23
The search resulted in 23 jobs both AIP and non AIP
Identifies AIP job
Immediate Available - Jobs with a fill date from now to 5 months away. More Info
Open Reqs - Jobs with a fill date from 6-9 months away. More Info


WEB JASS
Home
Jobs
Edit/Review
Results
Notes
DATA XFER
Log Out
Review Jobs and Make Applications
Download Current Requisition for JASS Client:
DOWNLOAD
SPECIAL PROGRAM'S HOT PICKS
Required Input
Requisition Date: 10/19
Special Programs and Communities:
Optional Input
MCA
Composite
NEC
Checking this box identifies AIP jobs only
Location:
All Locations
SELECT
Unit Type:
All Units
SELECT
Job Category:
Immediate Avail
Open Reqs
G2K Options
Incentive
SEARCH
CLEAR
[Click on Activity Name to view details of job and proceed to application screen]
Jobs Found: 9
Displaying 1-9 of 9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Open Reqs
G2K Options
Incentive
SEARCH
CLEAR
[Click on Activity Name to view details of job and proceed to applicatio
Jobs Found: 9
Displaying 1-9 of 9
Limiting the search to only AIP jobs yields 9 jobs
Select this job for more details
SS WA MCA NEC1 NEC2 Rate UIC Activity Location Incentive
ate Available - Jobs with a fill date from now to 5 months away. More Info
ET1 41681 NCTAMS EC NAPLES ITALY, NAPLES
4 L 1466 0000 ET1 67562 FTSCLANT DET ITALY, NAPLES
3 L 0000 0000 ET1 55782 COMSUBGRU 8 ITALY, NAPLES
3 L 0000 0000 ET1 70294 NCTAMS EC NAPLES ITALY, NAPLES
3 L 2735 9502 ET1 62995 NAS SIGONELLA SICILY, SIGONELLA
3 L 0000 0000 ET1 43575 NCTS SIC SATCM SICILY, SIGONELLA
Open Reqs - Jobs with a fill date from 6-9 months away. More Info
3 L 2781 0000 ET1 70294 NCTAMS EC NAPLES ITALY, NAPLES
3 L 1493 0000 ET1 42232 NCTS S TSCD S SICILY, SIGONELLA
3 L 1458 0000 ET1 68893 NCTS SICILY IT SICILY, SIGONELLA
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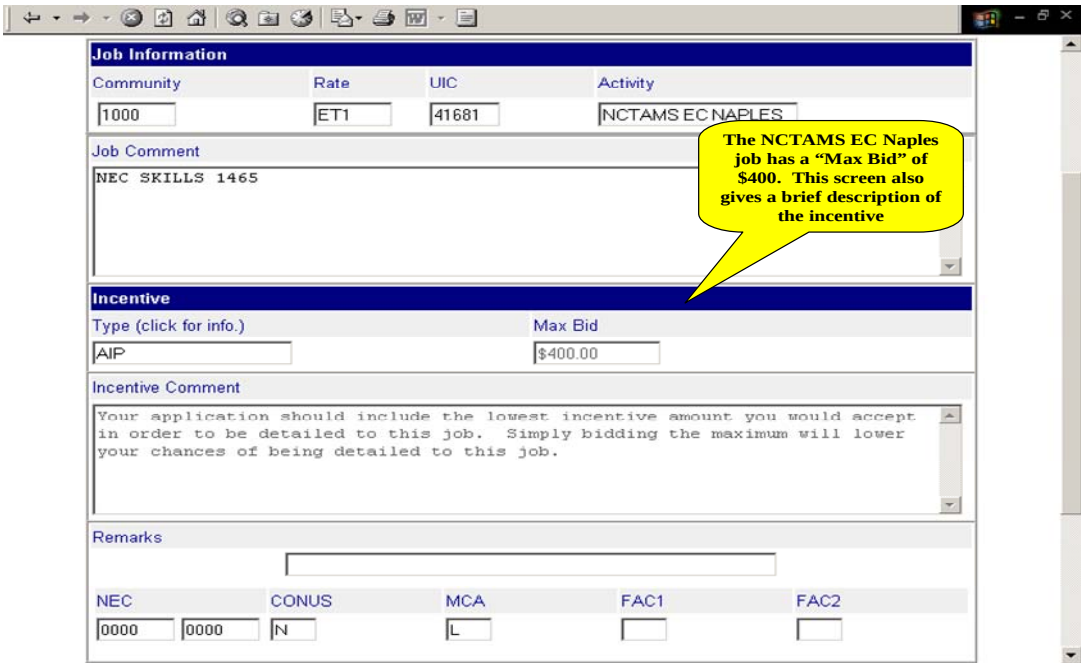
Last Updated: 02/21/2003 14:29:09


Job Information
Community
Rate
UIC
Activity
1000
ET1
41681
NCTAMS EC NAPLES
Job Comment
NEC SKILLS 1465
The NCTAMS EC Naples job has a "Max Bid" of $400. This screen also gives a brief description of the incentive
Incentive
Type (click for info.)
Max Bid
AIP
$400.00
Incentive Comment
Your application should include the lowest incentive amount you would accept in order to be detailed to this job. Simply bidding the maximum will lower your chances of being detailed to this job.
Remarks
NEC
CONUS
MCA
FAC1
FAC2
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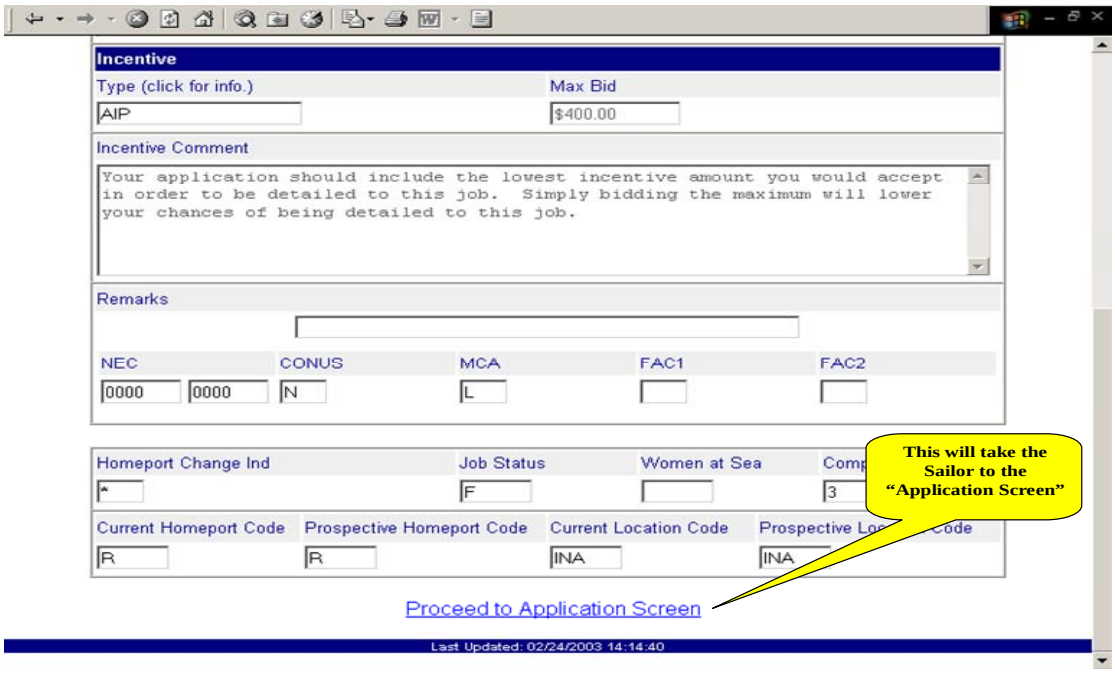
Incentive
Type (click for info.)
Max Bid
AIP
$400.00
Incentive Comment
Your application should include the lowest incentive amount you would accept in order to be detailed to this job. Simply bidding the maximum will lower your chances of being detailed to this job.
Remarks
NEC
CONUS
MCA
FAC1
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L
Homeport Change Ind
Job Status
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*
F
3
Current Homeport Code
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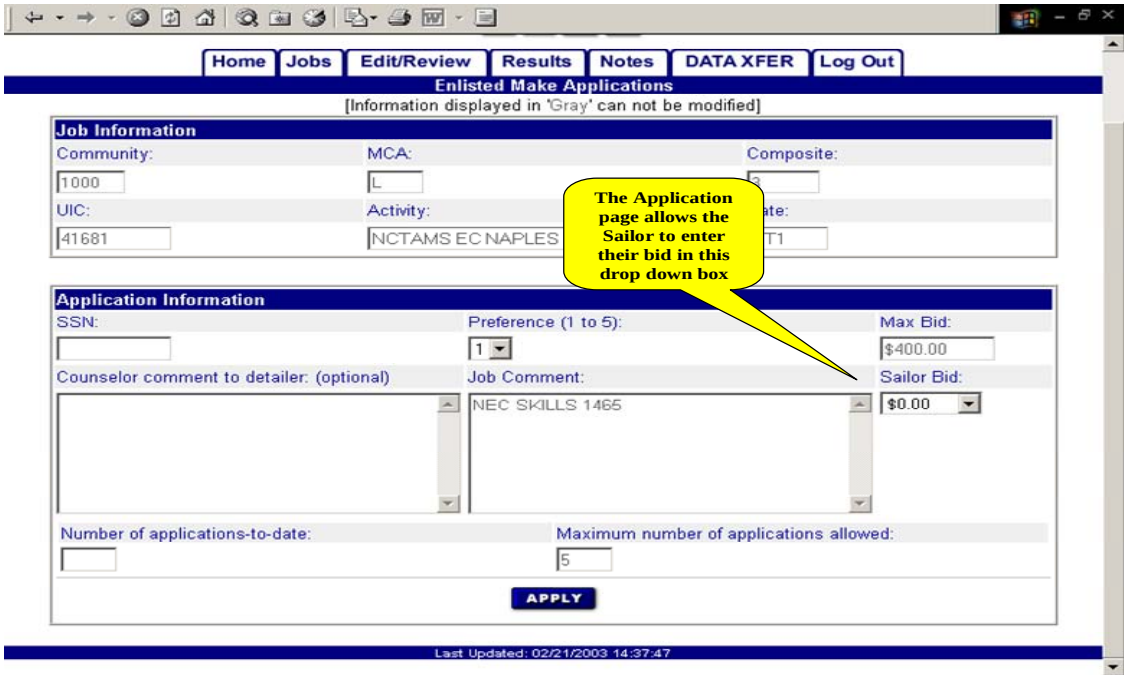
INA
This will take the Sailor to the "Application Screen"
Proceed to Application Screen
Last Updated: 02/24/2003 14:14:40


Home
Jobs
Edit/Review
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DATA XFER
Log Out
Enlisted Make Applications
[Information displayed in 'Gray' can not be modified]
Job Information
Community:
MCA:
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L
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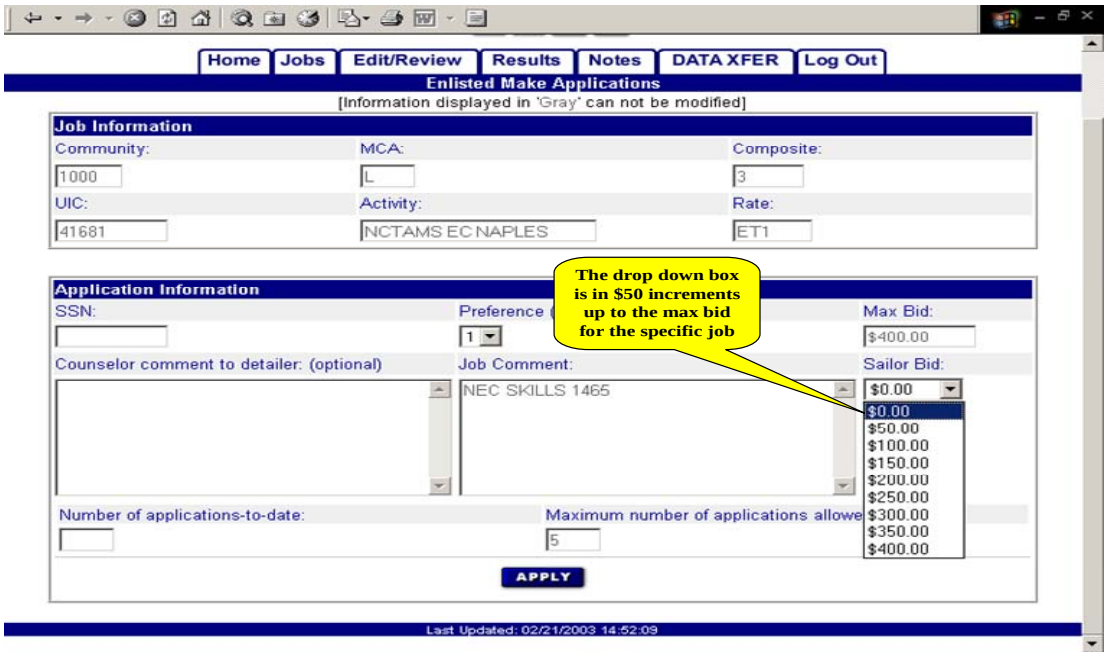
41681
NCTAMS EC NAPLES
The Application page allows the Sailor to enter their bid in this drop down box
Application Information
SSN:
Preference (1 to 5):
Max Bid:
1
$400.00
Counselor comment to detailer: (optional)
Job Comment:
Sailor Bid:
NEC SKILLS 1465
$0.00
Number of applications-to-date:
Maximum number of applications allowed:
5
APPLY
Last Updated: 02/21/2003 14:37:47


Home
Jobs
Edit/Review
Results
Notes
DATA XFER
Log Out
Enlisted Make Applications
[Information displayed in 'Gray' can not be modified]
Job Information
Community:
MCA:
Composite:
1000
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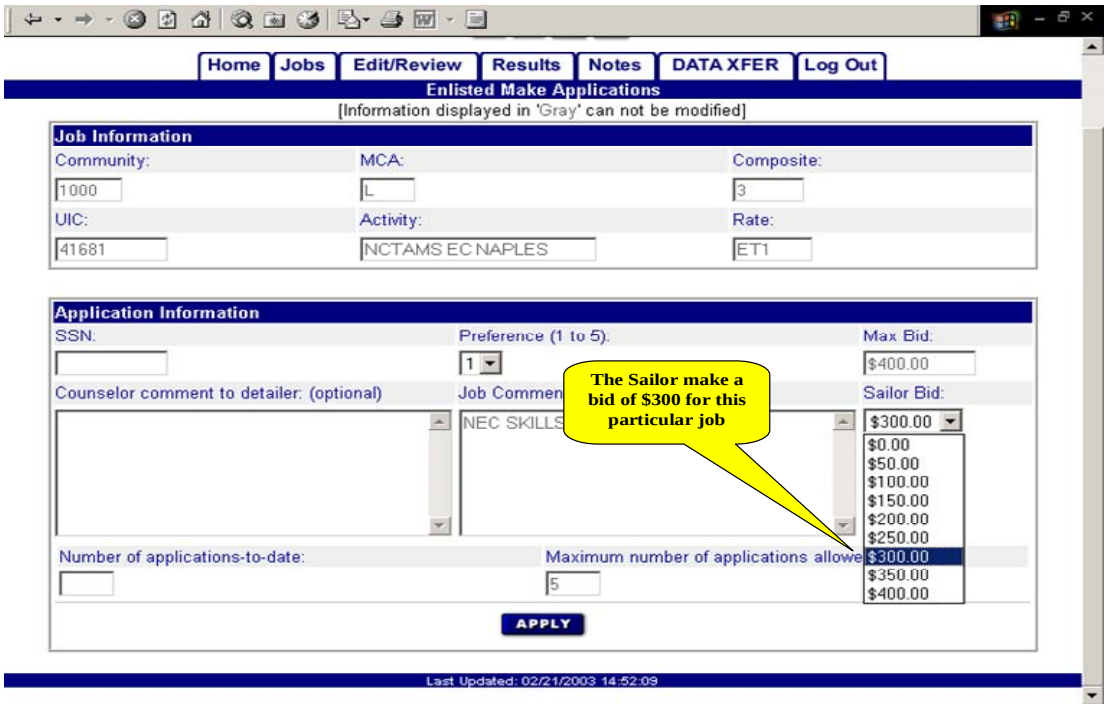
3
UIC:
Activity:
Rate:
41681
NCTAMS EC NAPLES
ET1
Application Information
SSN:
Preference
Max Bid:
1
$400.00
Counselor comment to detailer: (optional)
Job Comment:
Sailor Bid:
NEC SKILLS 1465
$0.00
$0.00
$50.00
$100.00
$150.00
$200.00
$250.00
$300.00
$350.00
$400.00
Number of applications-to-date:
Maximum number of applications allowe
5
APPLY
Last Updated: 02/21/2003 14:52:09
The drop down box is in $50 increments up to the max bid for the specific job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Composite:
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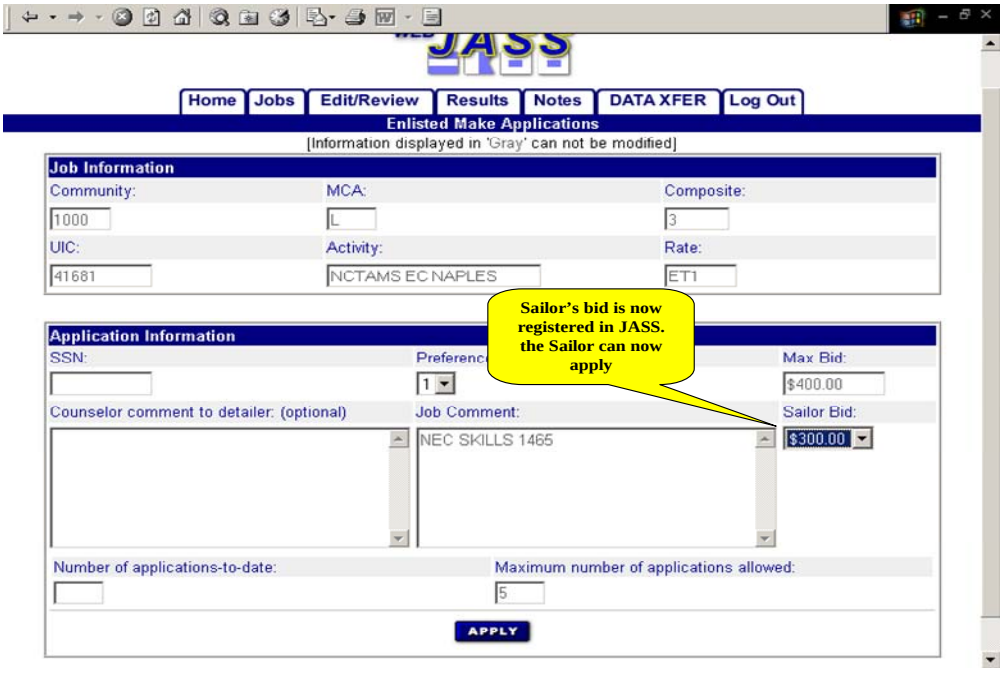
Activity:
Rate:
41681
NCTAMS EC NAPLES
ET1
Application Information
SSN:
Preference (1 to 5):
Max Bid:
1
$400.00
Counselor comment to detailer: (optional)
Job Commen
Sailor Bid:
NEC SKILLS
$300.00
$0.00
$50.00
$100.00
$150.00
$200.00
$250.00
$300.00
$350.00
$400.00
Number of applications-to-date:
Maximum number of applications allowe
5
APPLY
Last Updated: 02/21/2003 14:52:09
The Sailor make a bid of $300 for this particular job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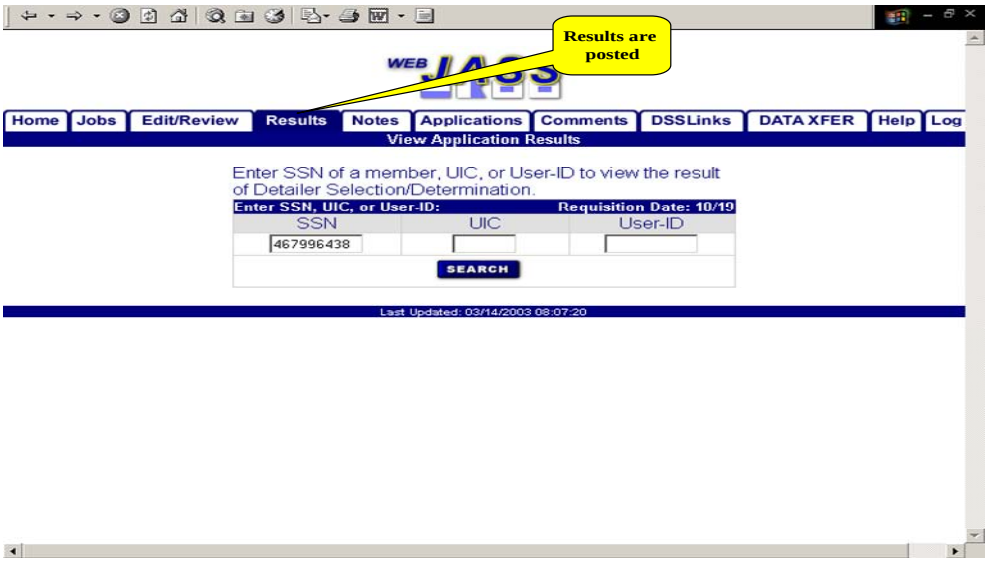
UIC:
Activity:
Rate:
41681
NCTAMS EC NAPLES
ET1
Sailor's bid is now registered in JASS. the Sailor can now apply
Application Information
SSN:
Preferenc
Max Bid:
1
$400.00
Counselor comment to detailer: (optional)
Job Comment:
Sailor Bid:
NEC SKILLS 1465
$300.00
Number of applications-to-date:
Maximum number of applications allowed:
5
APPLY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Enter SSN of a member, UIC, or User-ID to view the result of Detailer Selection/Determination.
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Requisition Date: 10/19
SSN
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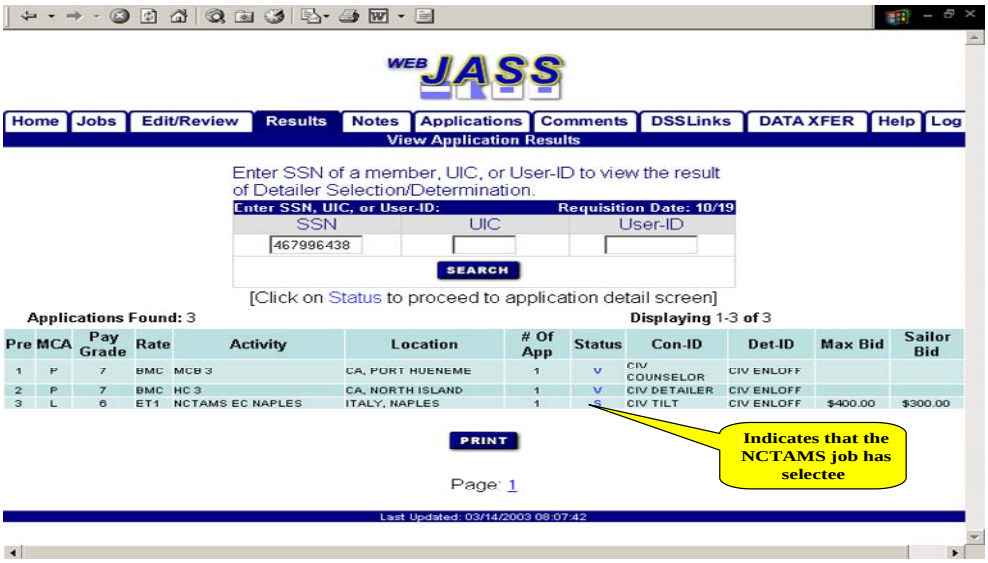
User-ID
467996438
SEARCH
Last Updated: 03/14/2003 08:07:20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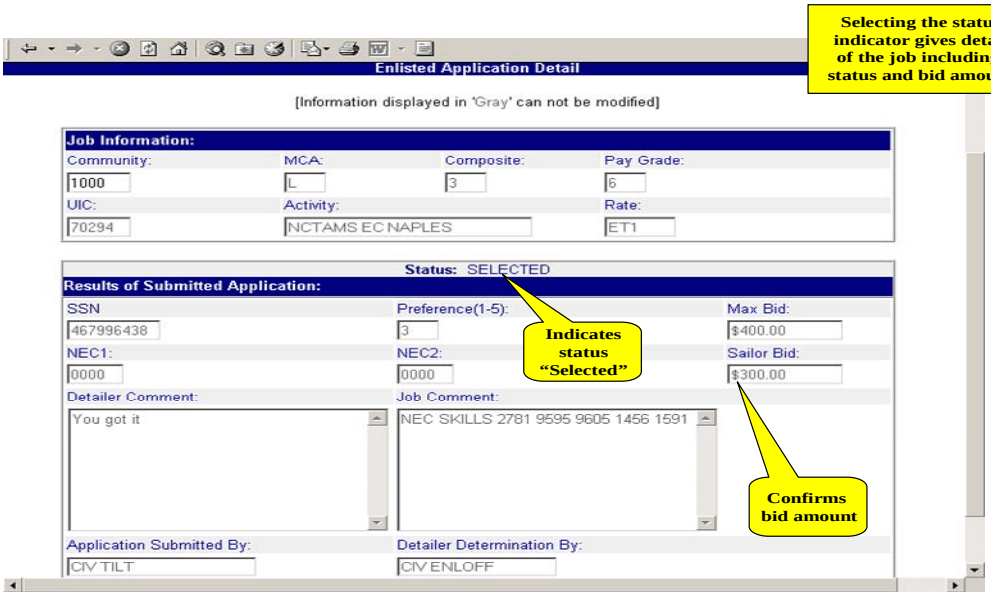
Help
Log
View Application Results
Enter SSN of a member, UIC, or User-ID to view the result of Detailer Selection/Determination.
Enter SSN, UIC, or User-ID:
Requisition Date: 10/19
SSN
UIC
User-ID
467996438
SEARCH
[Click on Status to proceed to application detail screen]
Applications Found: 3
Displaying 1-3 of 3
Pre
MCA
Pay Grade
Rate
Activity
Location
Of App
Status
Con-ID
Det-ID
Max Bid
Sailor Bid
1 P 7 BMC MCB 3 CA, PORT HUENEME 1 V CIV COUNSELOR CIV ENLOFF
2 P 7 BMC HC 3 CA, NORTH ISLAND 1 V CIV DETAILER CIV ENLOFF
3 L 6 ET1 NCTAMS EC NAPLES ITALY, NAPLES 1 S CIV TILT CIV ENLOFF $400.00 $300.00
PRINT
Page: 1
Last Updated: 03/14/2003 08:07:42
Indicates that the NCTAMS job has selectee


Selecting the status indicator gives detail of the job including status and bid amount
Enlisted Application Detail
[Information displayed in 'Gray' can not be modified]
Job Information:
Community:
MCA:
Composite:
Pay Grade:
1000
L
3
6
UIC:
Activity:
Rate:
70294
NCTAMS EC NAPLES
ET1
Status: SELECTED
Results of Submitted Application:
SSN
Preference(1-5):
Max Bid:
467996438
3
$400.00
NEC1:
NEC2:
Sailor Bid:
0000
0000
$300.00
Indicates status "Selected"
Detailer Comment:
Job Comment:
You got it
NEC SKILLS 2781 9595 9605 1456 1591
Confirms bid amount
Application Submitted By:
Detailer Determination By:
CIV TILT
CIV ENLOFF

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   Naval Postgraduate School
   Monterey, California

5. Senior Lecturer John Mutty
   Naval Postgraduate School
   Monterey, California